

Theology on the Web.org.uk

Making Biblical Scholarship Accessible

This document was supplied for free educational purposes. Unless it is in the public domain, it may not be sold for profit or hosted on a webserver without the permission of the copyright holder.

If you find it of help to you and would like to support the ministry of Theology on the Web, please consider using the links below:



Buy me a coffee

<https://www.buymeacoffee.com/theology>



PATREON

<https://patreon.com/theologyontheweb>

PayPal

<https://paypal.me/robbradshaw>

A table of contents for *Journal of the Transactions of the Victoria Institute* can be found here:

https://biblicalstudies.org.uk/articles_jtvi-01.php

JOURNAL OF
THE TRANSACTIONS
OF
The Victoria Institute,
OR,
Philosophical Society of Great Britain.

EDITED BY THE HONORARY SECRETARY.

VOL. IX.



LONDON:

(Published for the Institute)

HARDWICKE & BOGUE, 192, PICCADILLY, W.

1876.

ALL RIGHTS RESERVED.

ORDINARY MEETING, FEBRUARY 1, 1875.

C. BROOKE, ESQ., F.R.S., V.P., IN THE CHAIR.

The minutes of the last meeting were read and confirmed, and the following Elections were announced :—

ASSOCIATES:—Major J. H. Lutman, Shepherd's Bush ; Rev. T. H. Clark, M.A., Clifton ; Rev. Edgell Wyatt-Edgell, Lutterworth.

Also the presentation of the following Works to the library :—

- | | |
|---|--------------------------|
| "Transactions of the Royal Society," Part 157. | <i>From the Society.</i> |
| "Transactions of the Geological Society," Part 120. | <i>Ditto</i> |
| "Transactions of the Society of Biblical Archæology," Part 1, Vol. III. | <i>Ditto</i> |
| "Theism and Modern Science." By Professor G. Salmon, D.D. | <i>Ditto</i> |

The following paper was then read by the author :—

THE INDESTRUCTIBILITY OF FORCE. By the Rev. CANON BIRKS, M.A., Professor of Moral Philosophy in the University of Cambridge.

THE Indestructibility of Force is one main pillar of that Fatalism which has lately been proclaimed by various writers as some grand discovery of modern science. According to Dr. Tyndall, "it binds nature fast in fate to an extent not before recognized," and is "an idea of the widest grasp and radical significance." Applied first to inorganic, it has rapidly embraced organic nature, and "brings vital as well as physical phenomena under its dominion." Nay, according to Mr. Spencer, the leading exponent of the new philosophy, it is an "*à priori* truth, which lies deeper than any other, and transcends both experience and demonstration" (F. Pr., pp. 189, 192). But before we resign our faith in prayer and worship, in God, Christ, and immortality, to this alleged discovery, let us look it closely in the face, and try to fix its real meaning. Rapid growths are suspicious. So are self-evident truths, discovered only yesterday. Mushrooms, in science as in nature, may grow up in a night ; but forest oaks are slower in their growth, and commonly need centuries to mature.

The doctrine has various names,—the Conservation, the Inde-

structibility, or the Persistence of Force, and the Conservation of Energy. The first has been perhaps the most usual. But Professor Huxley and Mr. Spencer detected in it a serious defect. Conservation seems to imply a Preserver, and an act of conserving. But this jars on the instincts of the new school of materialism, and contradicts its doctrine of the Unknowable. They propose, then, the Persistence of Force as a better name. But their object is hardly attained. Language is obstinate, and brings in moral ideas, in spite of the most careful efforts to exclude them. Persistence, as the dictionaries tell us, means "perseverance in a good or evil course, usually in one injurious," "obstinacy or contumacy." It naturally implies a persevering action in spite of remonstrance or opposition. If the phrase, then, gets rid of the idea of a Preserver and Moral Governor, what does it introduce in its stead? A deaf, blind Fate, which will persist in its course, heedless of all complaints from victims whom it tramples to death, or any attempted control by human or Divine intelligence. The idea it suggests is of the broomstick in the tale, that would persist in carrying buckets of water, till its owner's house was deluged. He cut it in pieces, but the charm was strong in each fragment, and it carried the more. "The mere machine saw and understood nothing. Insensible and without fatigue, it would have carried into his house the whole river." But a higher power, gifted with reason, interposed. The charm was reversed, just in time to avert a great catastrophe, and the senseless, persistent thing persisted in its work no more.

The other variation is still more important, and affects the essence and definition of the doctrine. This Titan of science, like Briareus in Homer, has two different names. It is Force with common mortals, but with analysts its name is Energy. And this is of two kinds, Kinetic and Potential. The conservation is of their sum, and is a privilege which belongs to neither of the two partners, but to the partnership alone.

The Indestructibility of Force, its name with Dr. Tyndall, is a vague expression, and may mean three or four different things. First, the indestructibility or invariableness of Force Proper, as defined in Newton's laws, and dynamical science. Secondly, that of Force improper, that is, of motion or momentum, measured either by the velocity or its square. It will then assert the constancy of the collective or total motion of the universe. Thirdly, it may be the constancy of a Potential function, depending on the laws of force, either actual or supposed. Lastly, it may mean the constancy neither of force nor motion, but of a sum formed from both by some rule or process of dynamical science.

The nucleus of truth in the doctrine, around which has gathered no slight amount of ambiguity and pretentious falsehood, consists of three main elements.

First, a separate fluid of Heat or Caloric, the usual theory of last century, and the basis of the treatises of Fourier and Poisson, has been set aside. The earlier view of Lord Bacon, that heat is a special form of atomic motion, held since by Locke, Rumford, and many others, has gained a complete triumph. By the skilful researches of Joule, Seguiet, Thomson, and others, the number of feet of elevation, which answer in mechanical force to a degree of temperature, has been very nearly determined. In an age of steamboats and railroads, such a determination is of value to engineers, and is well adapted to arrest the popular mind, and seal the triumph of the corrected theory. But in point of abstract science, it is a detail of slight importance. Some such equivalence is a self-evident result, when the view of heat as atomic motion has once been received.

The second truth is wider and more comprehensive. The walls, which parted asunder different classes of motion, or modes of atomic force, have been slowly removed. Hypothesis took the form, in the last century, of inventing distinct fluids for each main set of phenomena to be explained. Thus, in different works, we had one or two kinds of electric fluid, one or two of magnetic, a separate fluid of heat or caloric, and a luminiferous ether, or else a substance of light, shot out with immense velocity. But the progress of research has broken down these artificial barriers. Electro-galvanism, electro-magnetism, thermo-electricity, thermo-magnetism, actinism, and the polarization of heat and light, have bridged over the limits of separation. A heptarchy of sciences has been changed into an united monarchy. All these phenomena are now referred to one ethereal medium, in conjunction with ponderable matter; while some hold that even this is not required, and refer all these changes to the affections of matter alone.

The third element is more important. Let us assume the only forces of a system to be of the same class with gravitation, —attractions or repulsions, that depend only on the distance of the atoms, and increase by some definite law when the distance is lessened. A simple relation between the initial and final distances, and the motions produced, will then result from pure dynamical reasoning. However complex the system and its motions, the amount of motion generated or destroyed will not depend on the paths of the particles, but on the first and last distances alone. This truth, under the old name, *Conservation of Vis viva*, has been familiar to mathematicians ever

since Newton's days. But its application was limited by the opinion, common to Newton and many others, that the atoms, being finite and hard, might collide with each other. In this case motion would be destroyed when they met with opposite velocities, and the formula would fail. But all later researches have rendered this hypothesis of atomic collision less and less probable, though they can hardly be said to have proved its falsehood. And thus the *Conservation of Vis viva*, from a mere conception or hypothesis, has risen into the dignity of a probable fact, so far as physical forces are concerned, in the actual constitution of the material universe; and some analysts have coined for it this new name, the Conservation of Energy.

This old formula of dynamics, borrowed from mathematicians, has passed into the hands of experimentalists in physics and physiology. It then becomes the Indestructibility of Force, and is announced as a grand scientific discovery of the last thirty years. Mr. Spencer, the great apostle of evolution, goes a step further. He calls it the Persistence of Force, and affirms it to be no result of experience, but an ultimate, self-evident truth, of which no inductive proof is possible. Its denial is a pseud-idea, and unthinkable. The human mind, he says, is incapable of thinking the opposite. It is a truth "defying contradiction, and transcending demonstration." Even this does not exhaust its claim on our faith: it is "the sole truth which transcends experience."

But let us descend from this lofty cloudland, this extreme dogmatism of a wholly sceptical philosophy, to the humbler region of plain reason and common sense. Before we can decide the controversy whether this doctrine is true or false, a great recent discovery, or a greater *à priori* truth, which men have always held and could not help holding, because its opposite is unthinkable, or itself a demonstrable falsehood, the mere product of confused thought, we must first settle what it really means. Is it Force or Energy of which it speaks? Or are Force and Energy the same? If distinct, is the doctrine true of both, or of either? Is the indestructibility by human power only, or by any power, human or divine? Is it a conservation without any preserver, or a persistence without any person or thing that persists and perseveres? Is it indestructibility when no one attempts to destroy, and when there is no existence, nothing but an abstract quality, or the mere total of an arithmetical reckoning, to be destroyed? Let us try to unravel this tangled skein, so that we may see clearly the true character of this great experimental discovery, or still

greater *à priori* truth, which some would instate like a divinity on the throne of the universe.

Force, by the usual definition, involved in Newton's first and second axioms, and accepted in all works of exact science, is that which produces or tends to produce or destroy motion. To this definition two objections have lately been made, but wholly groundless. The first is that change in the state of matter with respect to its rest or motion may be produced by other matter in motion without the intervention of any force. But this is a radical misconception. A moving body does not alter, and cannot be conceived to alter, the state of another, except by the intervention of force. When the force varies with the distance, the motion of course alters its amount. Thus there may be immense repulsion occasioned by impact or apparent contact. But assume the absence of attractive or repulsive force altogether, and the motion of one body will have no effect at all on any other. Again, it is said that the resistance of a support is obviously not a force, but a statical pressure. It is, however, obvious that it is a force, *because* it is a statical pressure. For this really answers to one half of the definition. A pressure is a force which *tends* to produce motion, without actually producing it, because it is met and balanced by another.

Let us now begin with the postulate which the doctrine plainly requires, to assume a definite form. Let us conceive the universe to consist of atoms, finite in number, or else all our calculations and reasonings will fail, but inconceivably numerous, and acted on by no forces but of mutual attractions and repulsions, which lessen as the distances increase. Let us further take Force in its proper sense, just defined, on which the Principia and all trains of strict dynamical reasoning depend. Is the total of force, in such a universe, fixed, constant, and invariable? It is one of the simplest truths of Dynamics that it varies continually, from hour to hour, from moment to moment. If attractive forces are in excess, it increases in a condensing system, and decreases with dilatation. With repulsive forces it is the reverse. But it never for a moment continues the same. Of Force properly so called, the doctrine is not true at all, but exactly reverses the real truth.

But Force is the cause of motion, and the motion caused by it often borrows the name. Thus momentum, or the mass multiplied by the velocity, is viewed as a kind of variety of force, and *Vis viva*, or living force, is used to express the amount of motion, as measured by the product of the mass and the square of the velocity. Is the statement true of the *Vis viva* of a system, or the force in this improper sense? On the

contrary, the same remark applies as before. In a system under attractive forces, the motion, like the force, increases when the system contracts, and lessens when it expands. With a system of repulsive actions it is the reverse. But in either case, or a combination of both, the motion is not constant, but may increase continually, from a state of absolute rest to one of immense and ceaseless activity.

The maxim then, that Force is constant, indestructible, and unvarying, whether the term be taken in its strict and proper, or in its less proper and secondary meaning, is quite untrue. It varies in amount continually, with every change in the system to which the forces and motions belong. Let us see whether Mr. Spencer can throw any light on this great difficulty. How does he show that it is a self-evident, *à priori* truth, of which the opposite is inconceivable?

The proof he offers consists of two elements. First, we cannot measure and compare forces without assuming a unit of force. Now this unit is arbitrary. We can never prove by experience that it does not vary. Thus an *à posteriori* proof of the constancy of Force is impossible. Therefore, since it is certainly true, and cannot be proved by any amount of experience, it must of course be an *à priori* truth (F. P., pp. 185-188).

The desired conclusion is thus reached with surprising facility. And plainly there is no falsehood which may not be promoted into an *à priori* necessary truth, in the same easy way. First, assume it to be true. Next, show that no experience has proved it, or can prove it. It will then result at once that it must be an *à priori* truth.

The second part of the proof is equally simple. The equality of action and reaction is Newton's third law, and assumed in nearly all dynamical reasoning. But to assert this is to assert that force is persistent.

Now, first, Newton gives four pages, after stating the law, to prove it by various experiments. This is a strange warrant for the doctrine that it is true *à priori*, and that the converse or negation of it is inconceivable. Next, in a recent work on molecular mechanics, a denial of this principle is assumed in the main hypothesis, and the results of this unthinkable idea are thought out, through nearly three hundred pages of calculation and reasoning. But besides this double disproof of Mr. Spencer's assertion, the Persistence or Constancy of Force, and the equality of Action and Reaction, are wholly distinct and almost independent in their meaning. Let us take the simplest case. Let two attracting atoms fall towards each other in a straight line. Their action and reaction

are equal and opposite. A pulls B, and B pulls A, to the same amount, but in opposite directions. And the result is not the constancy either of force or motion, but their continual increase from zero to an infinite value.

In short, the Persistence of Force, in Mr. Spencer's treatise, means four or five different things, one wholly irrelevant, the rest inconsistent, untrue, and even absurd. First, it is Newton's third law, or the equality of action and reaction. "To assert that action and reaction are equal and opposite is to assert that Force is persistent" (p. 188). This is a truth, but one wholly distinct from the one with which it is confounded. Next, it is the same with the non-annihilation of matter, which means that "the force a given quantity of matter exercises, remains always the same" (p. 177, § 54). Thirdly, it is the constancy of each force in any system of forces; for "to conceive one or more of the forces to have increased or diminished is conceiving that force is not persistent" (p. 193, § 53). Fourthly, it is the constant variation of all forces, attractive or repulsive, by the law of the inverse square. For this law, we are told, is no discovery of Newton, but the inalienable possession of every thinker from the beginning. It is not simply empirical, but is deducible mathematically from the relations of space, and one of which the negation is inconceivable. We are thus taught the double *à priori* truth, that forces cannot be thought of as varying at all, and must be thought of as always varying in one particular way. Lastly by the persistence of Force "we really mean the persistence of some Power which transcends our knowledge and conception. In other words, asserting the persistence of Force is but another mode of asserting an unconditioned Reality, without beginning or end" (p. 189). Thus its final sense is the known and certain continuance, through all time, of some Being or Power wholly unknown, or the constant invariable sameness, in quantity, of some Power wholly inscrutable, and thus incapable of any measurement whatever.

To find what we seek, we must escape from this quagmire of contradictions, and turn to the mathematicians. Their phrase is different, not the Persistence of Force, but the Conservation of Energy. Let us try to learn what it really means.

Force, in dynamics, is the cause of motion, and distinct from the motion it causes. Suppose the force to cease, and the motion caused by it will continue. Let the force still act, and the velocity or motion is increased. Let some opposite force act, and the motion is diminished. Now let two bodies act on each other by a law of force, which depends on the inverse distance, and their motion be measured by the square of the

velocity. Then a certain amount of motion is produced, when they pass from one given distance to another. In repulsive forces, the motion is increased when they recede, and in attractive forces, when they approach nearer. The change in the total motion when so measured, does not depend on the path, but on the initial and final distances alone. The old name of the motion, thus increased or diminished, is *Vis viva*, and the new one, not at all clearer, Kinetic Energy.

In the same case, we may calculate, or express by algebraic symbols, the total amount of force which is exercised in passing from any one distance to another. Such a total, when reckoned, from the actual distance to some natural limit, if such can be found, may be called by the new name, Potential Energy.

The result, in the case of repulsive forces, takes a simple form. The motion increases as the system dilates, and the bodies or particles recede from each other. But the Potential Energy, in repulsive force, has for its natural limits the actual distance and infinity. For then the force of repulsion would vanish, and it becomes less and less, as the distances increase. Thus, the motion or Kinetic Energy increases, and the Potential Energy, a right unit being assumed, decreases by a like amount. Their sum, therefore, or the Potential plus the Kinetic Energy, will be constant and invariable.

But in all cases of mutual attraction there is a serious difficulty. For by such force bodies do not pass from a finite to an infinite distance, but from a greater to a less, from a finite distance to coincidence. Thus the Potential Energy, if reckoned as before, between the actual distance and infinity, where the force vanishes, has a wrong sign. It increases with the increase of the acquired motion, and not their sum, but their difference, will be constant. As a mere matter of calculation, the case is easy. The Potential of an attractive force, if reckoned from zero to its value at any finite distance, must have a negative sign. The total Energy, if the system has started from rest at any finite distance, will be negative also. But if this Energy be taken for the supreme and ultimate power of the universe, a kind of Divinity, to make it an algebraic quantity with a negative sign is too ridiculous. Also to assume an arbitrary distance, within which no attraction can be exercised, contradicts the law, which recognizes no limiting distance. Thus, to save the theory, the Potential Energy, in attractive powers, must be reckoned from the actual distance to coalescence. But then the force, and its total sum, the Energy, become infinite and immeasurable.

The Conservation of Energy thus denotes the constancy of a total formed from three distinct elements. (1) The Kinetic Energy, or sum total of motion. (2) Repulsive Potential Energy, reckoned from the actual to an infinite distance. (3) Attractive Potential Energy, reckoned from the actual distance to zero, where its amount is infinite. But if the repulsive and attractive vary by a mixed law, so as to give a neutral distance, the Repulsive and Attractive energies must be reckoned alike from the actual to the neutral distance, but in opposite directions.

Such is the exact nature of the Conservation of Energy, as a mathematical formula within its own proper limits. It implies and requires a special hypothesis as to the nature of the acting forces, and deduces an important and useful dynamical result. But when turned into an alleged discovery, the result of recent physical induction, or into an *à priori* truth, which enables us to explain the universe without a Divine author, it is transformed into a condensed cluster of logical fallacies and metaphysical contradictions.

And first, this indestructible total, always the same, is a numerical and not a real total. Force, the cause, is not the same with motion, the effect. When a body moves uniformly in a right line, there is motion but not force. When two bodies press oppositely against a third with equal pressure, there is force but no motion. Take any frustum of a paraboloid with a circular base. Take the whole height of the paraboloid for the unit of height, and the circular base for the unit of surface. Then the sum of the height of any frustum, and of the circular top, measured in fractions, will always be unity. But this constant total is a mere numerical abstraction, since a height cannot really be added to a surface, being different and heterogeneous in kind. Thus the alleged doctrine, that force is indestructible, because the total of two kinds of energy is constant, turns a numerical relation into a chimera, devoid of real meaning.

Fallacy the second. Let us waive this first decisive objection, that force and motion are not the same, that a real total cannot be formed of unlike elements by any device, and least of all by confounding them under an ambiguous name; that each of them separately is highly variable, and that what is really constant is a numerical abstraction, and nothing more. Let us admit the power of this name, Energy, to fuse into one total unchangeable and indestructible, these unlike elements, Potential Energy, or force, and Kinetic Energy, or motion. We may at least claim that both elements which compose the

grand total shall actually exist. The *Vis viva*, or Kinetic Energy, does exist. Its amount is the total motion of the system, measured by the square of the velocity of each particle at any moment. But the case of the Potential Energy is just the reverse. It is composed, not of forces that now exist, but of possibilities of forces that would exist hereafter under conceivable conditions of change. The Potential Energy of a pair of atoms, if the force is simply repulsive, is the total of force that they would exert on each other in receding from the actual to an infinite distance. If the law is simply attractive, it is the like total, exerted on each other in approaching nearer to absolute coalescence. If the law is mixed, with repulsion for small distances, and attraction for the rest, then the Potential Energy is the total of force that may be exerted in passing from the actual to the neutral distance. And thus the entire Potential Energy is not the force existing at the present moment. It is a total of the force that may or might be hereafter exercised through as many different periods of conceivable future time as there are pairs of atoms in the whole universe.

To make this objection clearer, let me adopt the same license in a similar case. I wish to prove that the number of persons in the streets of London from day to day is constant and unvarying. And I succeed in this way. First, I note in thought those actually present in the streets this day, and call it the kinetic street population. Next, I contemplate the vast number who, under social laws and conditions, have been determined to use the streets every past day since the city was peopled, and call it the Past Potential of street population. Next, I form a Future Potential of all those who will, under the laws of London life, be led to walk in its streets through all the successive days of its future existence. I sum these three elements, and their total is of course invariable. Here, then, we have the *à priori* basis of a new Sociology, that the number walking in London streets, actual and potential, has never varied, and cannot vary to the remotest age.

Fallacy the third. This total Energy, said to be invariable, is the sum of the actual motions, and of two potencies, measured from the actual to an infinite distance in repulsion, to zero or coalescence in attraction, but in a mixed law to the neutral distance, under the assumed conditions, on which the formula for Energy depends, that attracting points can only come nearer, and repelling points recede. But the real conditions are different, and almost opposite. Each atom, in approaching some, recedes from others. Forces act not only to create or increase velocities, but to lessen or destroy them. In moving

from distance A to distance B, a potency of acceleration disappears. But it is replaced at once by an equal potency of retardation, when the same distance is traversed the opposite way. Now Force is equally Force, whether it accelerates or retards. Thus, when the distance varies, the entire Potential Energy is really unchanged, and one part of it simply changes its name or direction, being the same in amount as before. On the other hand, the motion or Kinetic Energy varies every moment. The sum of both, or the motion plus the Potential Energies, must therefore vary just as much as the motions themselves.

Fallacy the fourth. The doctrine not only confounds motions with forces, and actual motions with forces merely possible and conceivable, not actual, excluding one half of the real potencies themselves. It also involves a further defect, as fatal as the rest. These Potencies, for the main part, are real impotencies. The total is made up from all the forces that would act through all possible changes of distance, if each pair of atoms were left to their own mutual action alone, to the furthest limit. With a purely repulsive law, this involves a finite value, but an infinite distance, and an infinite time. With a purely attractive law, a finite time and distance, but an infinite amount or total. In a mixed law, with repulsion dominant at small distances, the repulsive Potential Energy, to resist union, is also infinite. Now these Potencies, to become real, with a trillion atoms, would require the fulfilment of a trillion times a trillion contradictory and impossible conditions. But our atoms cannot isolate themselves. They are bound by the laws of physics, even if the mind of man is free, and not bound by them. A main part of the Potential Energies are real impotencies, because the co-existence of the other atoms forbids the very condition on which the existence of these potencies depends.

Fallacy the fifth. The whole doctrine assumes that the separate energies, which compose the grand total, are finite and measurable. There is, on this view, a fixed amount of Force or Energy, which travels from atom to atom, and changes its form, but still remains always the same. "We must recognize the amounts as determinate, as necessarily producing such and such quantities of results, and necessarily limited to those quantities" (F. P., p. 203).

Here we meet a double and fatal objection. First, if the total be finite and measurable, who has fixed this limit? The unit of measurement is plainly arbitrary; but the amount or number of these units is arbitrary also. We can plainly conceive it greater or less than any finite value whatever.

What voice, then, has said to this mighty ocean of Primeval Force, Hitherto shalt thou come, but no farther, and here shall thy proud waves be stayed ?

By the laws of force, however, so far as science has detected or conjectured them, the force depends on the inverse distance, and will be infinite when two particles touch or coalesce. The energy, which is the integral of the force, will then become infinite also. What the doctrine, therefore, requires, is a vast summation of infinites, a strict, equated total, made out of trillions of trillions of things each immeasurable.

Such is the five-fold contradiction involved in the so-called Persistence, Constancy, or Indestructibility of Force, on its dynamical side. But the metaphysical or ontological falsehoods it involves are not less numerous.

The first of these is the same as with the twin doctrine, the Indestructibility of Matter. In the Neo-Lucretian philosophy God is a Being wholly unknowable and unknown. "The Power which the universe manifests to us is utterly inscrutable" (F. P., p. 146). And Force, too, like God and Matter, is wholly unknown. "It is a truism to say that its nature is inscrutable" (p. 170). "It is impossible to form any idea of Force in itself, and equally impossible to comprehend its mode of exercise or law of variation" (p. 61). Yet we are taught that this wholly unknown Being, whether he has a will to do it or not, cannot destroy one particle of this wholly unknown and unknowable thing or quality, which we call Force or Energy. Nay, we are assured that this is an *à priori* truth of the first order, on which all science is based, which every one has always believed without knowing it, and could not help believing. Can there be conceived, I would ask, a worse superlative of hopeless, incurable contradiction ?

Contradiction the second. The doctrine assumes that motion or Kinetic Energy is the same identical thing or quality with Potential Energy, because of a numerical equivalence, when reckoned in one especial way. But this is wholly untrue. A rectangle, when its breadth is the unit of distance, has its length and its area or surface expressed by the same number. But a length and a surface are not on that account the same. Kinetic Energy is the sum of the squared velocities, or the squares of the rates of speed at which every pair of atoms change their distance from each other. Potential Energy is the sum of all the pulling or pushing forces that might or would be exerted under a given law of force, in the change from one distance to another. A rate of actual speed, multiplied into itself, is one idea. A sum of pushes or pulls, not actual, but

possible in many successive instants to come, is clearly another. To call them the same thing transformed, because the number denoting them may be the same, is not more reasonable than to say that a company of travellers are the same with their own railway tickets, or that these tickets are the travellers themselves transformed. A cannon-ball is shot upward at the rate of a thousand feet a second. The doctrine affirms this speed or motion to be the very same thing with the place of that ball on the top of a mountain three miles high. But such an identity is metaphysically inconceivable, and practically absurd.

Contradiction the third. Motion, by the theory, may be transferred from one body to another, remaining the same motion still. It may reverse its direction, and be the same motion, if its rate be the same. On this assumption alone can the indestructibility or persistence of that part of the Energy, which consists of motions, be maintained. The motion is to be one and the same, whether it moves five feet a second northward, or rebounding from a wall, five feet a second southward; or whether B, after collision, moves five feet a second northward, and A is at rest; or whether A is at rest, and twenty-five other bodies move one foot a second northward, or whether B moves four feet a second in one direction, and C three feet a second at right angles, A being at rest. But the sameness and identity of motions, when neither the moving thing, nor the direction, not the speed is the same, but all in turn different, does violence to the fundamental laws of human thought. The transfer of motion, in a few simple cases, is a lawful and expressive term. It describes the fact by an easy figure. But when mistaken for a logical truth, and turned into the basis of a theory of the universe, it is wholly and palpably groundless. In a collision, the motion of the body arrested, and of the body impelled, are not and cannot be the same motion. They are not the same in the subject, and motion is the quality or state of a thing, not a separate existence. They are not the same in time, for one has ceased when they separate, and the other has no existence before contact. They are not the same even in direction, except in a very limited class of collisions. In short they admit of every conceivable kind of diversity.

Contradiction the fourth. The motions, which compose and form the Kinetic Energy, need to be abstracted from their direction, and from the particles or bodies which move, and when this separation has been made, to be summed in a total, which constitutes one main part of the new indestructible divinity. But by this severance, the motions neutralize each other, and the total disappears. In a universe, the parts of

which act and react on each other, the centre of gravity or action must be conceived immovable. There is just as much motion up and down, forward and backward, to the right and to the left. Real motions must be motions of something or other. If many motions are really summed into one motion, it must be the motion of some one thing or body. But when we thus dismiss the individual bodies, and retain as fixed and permanent the motions only, the plus and minus values neutralize each other. Thus the only result of the summation is not motion at all, but absolute rest. Treat these forces, not as attributes inseparable from particular bodies that move, but as things, like liquids, that may be poured from vessel to vessel, and they resolve themselves into a collective movement of nothing nowhither, and wholly disappear.

Contradiction the fifth. The Potential Energy supplies another element of confused thought and metaphysical incongruity, as striking as the last. It depends for its real existence on our confounding the present instant with millions on millions of finite periods of future time, or intervals of possible future change. The countless millions of periods, which every pair of atoms would require in passing from their actual distance to zero or infinity, are assumed to be all in present existence, and included alike in each passing moment. The Kinetic Energy is counted once only, through all successive instants, in the common part of it, however much it may be increased. But the Potential, whether it increases or diminishes, is reckoned over and over again, in the common part of it, however many instants of time there may be.

Contradiction the sixth. The theory affirms the force of the universe to be persistent and invariable in amount, but to undergo incessant changes of form only. It is indestructible as adamant, but exceeds Proteus himself in its capacity and appetite for transformation. But when Force is divorced from matter, of which it is the quality, and turned into a supreme divinity, these transformations are left without any cause or possible explanation. No higher Power or Will is allowed to interfere. Force, blind Force, must reign supreme, binding mind and matter alike in the bonds of fate, and admits of no rival near its throne. But why should it inflict on itself a perpetual self-torture? Why cut itself, from moment to moment, into innumerable sections or fragments, no sooner reunited, than triturated with new divisions without end? Why is this Force, our new divinity, condemned to a fate like that of the wandering Jew, so as to rove from atom to atom, from world to world, throughout infinite space, with no limit to its wanderings, and no motive for its restless

change? Now it is solar force, and now terrestrial; now sensible in masses, now latent and atomic; now a wave of light, and now of sound; now buried deep in the earth, and now vanishing in the infinite azure of heaven. What other power compels the blind Titan to weary itself in these ceaseless transmigrations? We can easily conceive one body, endowed with active power, pushing or pulling, seeking or avoiding, another. But how can we conceive a particle of motion, which is not a thing that moves, but an abstract quality or relation, pushing or pulling another particle of the same force? And even were this conceivable, since our total includes all the force in the universe, what other force can remain by which this blind Samson of modern speculation is compelled to grind for ever in his dreary prison-house?

A last contradiction remains. The Indestructibility of Force, in its only definite sense, depends on our forming or conceiving a vast total of Potential Energies. This total consists of as many elements as there are pairs of atoms in the universe. Each element, again, can only be calculated by conceiving all the rest of the universe cancelled and destroyed, and that pair of atoms to exist and act alone. As each partial Energy can only be conceived and reckoned under this hypothesis, so it can have no real existence, unless this conception is restored. The theory, as taught by Mr. Spencer, thus involves an almost infinite amount of self-contradiction. It affirms, first, that the total quantity of matter in the universe cannot be conceived as diminished, any more than conceived to be increased (F. Pr., p. 143). Next, it affirms as a twin doctrine, a primary truth, transcending demonstration, the fixed, invariable constancy of the total Energy of the universe. Yet this constant total, for its very existence, requires not only the conceived, but the actual destruction of the whole universe, save two atoms, as many times repeated in each single moment as there are pairs of atoms in all its countless worlds.

The Persistence of Force, it thus appears, is no grand *à priori* truth, anticipating experience, and transcending demonstration. In the form it assumes in Mr. Spencer's work it condenses into one ambiguous phrase a dozen demonstrable errors and contradictions. The view in Dr. Tyndall's address, that it is at once a result of modern induction, and an *à priori* truth, needs no refutation. One alternative clearly excludes the other. On the other hand, the conservation of *Vis viva* is neither a proved conclusion, from ample scientific induction, nor a self-evident and necessary truth. It is the consequence which results from a conceivable hypothesis on the forces of the universe, that all

of them are functions of the inverse distance, and of that alone. It fails in three cases, all conceivable, one probable, and another certainly true: that the ultimate atoms are finite, and may come into direct collision; that forces exist, such as vital forces seem to be, depending on time as well as distance; and that selection or choice mingles with the action of force, so that all change is not blind, indiscriminate, and purposeless activity. And even when these cases are excluded, the constants of position, which are three times as many as the atoms of the universe, could never be determined by the mere laws of force. They must be explained by the will and foreseeing wisdom of the Supreme Architect and Governor of the universe, and can be reasonably accounted for in no other way. For, as Newton truly observes, "blind necessity, which is the same always and everywhere, could never produce this wonderful variety of natural things."

A third view has still to be examined,—that the Conservation of Energy, though not a necessary truth, is still a proved result of scientific induction. The author of the interesting paper on Force and Energy, read here two years ago, adopts this position. His doctrine is that the energy of the universe is shown by experiments to remain unchanged, not that it is unchangeable. The creation of matter, he says, must imply the creation of energy. Those who deny the possibility of one, must deny the other also. They must, in fact, deny the existence of Omnipotence. The writer complains, also, very truly, of the confusion and ambiguity with which these two names, Force and Energy, are often used. But his own definitions of them seem to me clearly erroneous, and the attempt to prove the principle as a universal, though not a necessary truth, wholly to fail.

Three fundamental errors have been already pointed out, which contradict the first principles of clear dynamical reasoning: that statical pressures are not forces, that friction is not a force, and that one body in motion can move another without the intervention of any force whatever. The last of these would reduce the whole science of dynamics to a heap of ruins, and undo and unteach all that Newton and his successors have taught and done.

The statements concerning Energy, and its relation to Force, seem to me plainly inconsistent, and neutralize each other. First, force is that which produces mutual attraction and repulsion (§ 8). Next, it is attraction or repulsion, a push or a pull (p. 28). The second statement is exact, and not the first. It cannot be attraction or repulsion, and something else which

produces them. But further, its character is "the power of imparting energy" (§ 8). Now since it has just been defined as a push or pull, or the power of imparting motion, it follows that motion and energy are the same. But "power of imparting energy" is denied to be a true definition, because "energy may be imparted by other matter possessing energy, without force" (p. 3, l. 14). And again, "energy is not, as frequently assumed, synonymous with motion." But by the definitions the only test of force is the impartation or extinction of motion, and if force may be characterized as a power of imparting energy, then energy is and must be motion.

But another definition is offered, the power of doing work. This merely transfers the obscurity to another word. For what is this work to be done? If not motion, or some change in the position of masses or atoms, what else can it be? But if the work to be done is moving things from one place to another, then force and energy come to be the same, as before energy and motion. Still further, in §§ 24, 25, light and heat are said to be accurately defined as "a very brisk agitation of the insensible parts of the object." Yet in § 29 we read that they "have frequently been illogically designated as 'modes of motion' by able physicists," and this "has led them into a hopeless confusion of the terms, force, energy, and motion." But a very brisk agitation is certainly a mode of motion, so that the paper is a fresh instance of that confusion of which its writer justly complains.

The source of all this perplexity seems to me very clear. Force is one distinct idea, motion is another. Force is the conceived cause of motion. Motion is the perceived effect of force. Each may be actual or possible. There are forces which now act, and others, different in amount, which may act in different circumstances. There are actual motions, and motions possible or conceivable. Energy is an ill-devised term for confounding together these different ideas, to gain thereby an apparent constancy which does not exist. Kinetic Energy is not force at all, but a sum total of actual motions. Potential Energy is not motion at all, nor actual force, but a sum total of conceivable forces under varied, non-existent conditions. The introduction of these ambiguous terms, instead of helping scientific insight, breeds endless and almost hopeless confusion. Energy is mistaken for a third thing, distinct alike from force and motion. It is not synonymous with motion. It is not synonymous with force. It is something which transfers itself, without force, from body to body, when motion is transferred, and yet is not motion.

Force has the power of imparting it, but energy can impart or transfer itself, without force. Heat, light, and the rest, are not forces, but forms of energy. They are brisk, vibratory agitation. Yet neither are they "modes of motion," but forms or kinds of energy. All this hopeless labyrinth of confusion arises from confounding two distinct ideas under one ambiguous name, and then fancying that we have discovered a third object of thought, distinct from both, and hereby effected a grand scientific discovery.

To recover clearness of thought we must hold fast this simple truth: Kinetic Energy is one thing, and Potential Energy another, quite distinct. The first is motion, the second, force, the conceived cause of motion. The first is actual motion. The second is not actual force, but a summation of possible future forces. Assume that forces depend only on the distances, and have acted and will act, only within limits of distance somehow defined; and the increase or diminution of motion will of course answer to the sum total of past force exercised; and when the remaining possibilities of force, up to the conceived limit, are added to this past effect, we shall have not really but numerically, a constant sum.

Like Force, Energy produces motion, and still is not Force. It is transferred when Motion is transferred, and is not Motion. Force and Motion both convey it, and still it is neither. Heat, Light, and Sound are not forces, nor, as some illogically say, modes of motion, but forms of energy. Yet Bacon and Locke have well defined the first, and might have defined the others, as "brisk, vibratory agitations."

All this confusion is the natural result of mixing up two ideas under one ambiguous name. Sometimes it means one, sometimes the other. All the properties of each may thus be affirmed and denied of it in turn, and with equal truth. Kinetic Energy has all the characters of motion, not of actual or possible force. Potential Energy has those of a sum total of possible forces, but not of actual force, or of actual or possible motion. This third something, called Energy, distinct alike from force and motion, is an idol of the marketplaces of science. It is an illusion and shadow, though some dare attempt to place it on the throne of the universe.

Let us examine the doctrine, freed from this ambiguous and deceptive phrase, on the side of induction and experience. The conservation of motion, to pass from an hypothesis into reality, requires three conditions to be fulfilled. First, in Physics, it excludes the notion of ultimate incompressibility, which Sir W. Hamilton and Mr. Spencer alike accept as a fundamental law

of thought. For motion would be destroyed by collision of finite atoms, which stop each other, without gradual repulsion, by their impenetrable extension alone. Next, in physiology, it excludes all forces which are functions of the time, or which begin at a fixed time, reach a maximum, and sink to zero at or within some given period. It excludes also discriminating attraction or repulsion, determined not by mere distance, but by relation to some type or model. Now these are exactly the two characters which life and living organic powers appear to possess. Thirdly, in humanity and theology, it excludes all forces which depend on the desires of sentient creatures, and the choice and will of a reasoning and moral agent, human or divine. The first of these three conditions is probable, but not yet proven. The second is both unproved and improbable. The third is not only unproved and improbable, but certainly and most mischievously untrue.

Mr. Brooke's paper on Force and Energy, on this higher side, is a total contrast to Mr. Spencer's Principles and Dr. Tyndall's address. Instead of binding nature fast in the bonds of fate, to the destruction of all morality and religion, he confines the doctrine to physics as its only legitimate scope, and views it, even there, as wholly subject to the wisdom and choice of an almighty and omniscient Creator. But within the limit of Physics the contrast ceases, and is replaced by a strange resemblance. Both Mr. Spencer and Mr. Brooke affirm the doctrine, almost with equal confidence, and both alike, without consciousness of the inconsistency, reject and set aside the conditions essential to its truth. My own theory of Matter and Ether, published twelve years ago, satisfies those conditions. I still believe it, if not true, to be a close approach to the truth, and a help to its future discovery, and expect that the real laws of nature, if different from those I have suggested, will equally fulfil these main conditions. But Mr. Spencer, who takes the doctrine for a necessary truth, and Mr. Brooke, who thinks its truth indisputable, from the inexorable logic of facts, and clear as the sun at noonday, deny four main premises, required for an intelligent acceptance of the doctrine, and thus reduce it to ashes with their own hands.

The Conservation of Motion, or the use of the Potential Function, as a dynamical formula, applies to any system, great or small, where all the forces are functions of the mutual distances of the atoms alone. To make it the known law of the universe, two things must be proved and known,—that such atomic laws do exist, and that no forces or powers operate

beside them. Its truth thus depends on these four formal conditions.

First, we must know, not only that atoms exist, but all the laws of force which exist between them. But Mr. Brooke affirms (p. 31) that we know nothing of their nature, and at the close of his paper repeats the statement once more. And Mr. Spencer lays down among his first principles that matter is inscrutable and unknowable, and that any force of matter on matter at a distance is inscrutable also. If so, the conservation of motion, according to one view, is unthinkable and inconceivable, and according to the other, wholly unproved and unknown.

Secondly, the doctrine involves the view of atoms as simply centres of force, not finite, impenetrable part of extension. And this for two reasons. Distances can only be strictly measured from some point, not from a bulk or space, for then the attraction or repulsion would have many different values at the same time, which is impossible. And next, these impenetrable atoms, by meeting, would destroy each other's motion. Hence Newton, who held this view of them, held, as the proper consequence, no conservation of motion, but its slow and ceaseless extinction. Yet Mr. Spencer sets aside the notion of force centres as wholly unthinkable, and Mr. Brooke includes it among those questions which are yet wholly unknown. Thus, by their own statements, a second main pillar of the doctrine is broken down and destroyed.

Thirdly, the doctrine requires the admission of an ether distinct from common matter. For if no forces exist but those which depend on the distance, and no kinds of substance but one, there can only be one single law of force, and that one is already known,—the law of the inverse square, or universal gravitation. It would follow that no repulsive force could exist, and no cohesion or electric action more powerful than gravity. The conclusion is plain. Repulsion and cohesion are evident facts; and we must either reject the condition on which the conservation of motion depends, or accept an ether of some kind, distinct in its laws of force from matter. Now Mr. Brooke, like Mr. Grove, denies the existence of such an ether. He conceives that matter, immensely attenuated in the planetary spaces, can transmit vibrations of light, or have an elasticity almost a billion times greater than that of the air, which causes the waves of sound. The contrast of direct and transverse vibrations only increases this difficulty, instead of removing it. For direct attraction or repulsion must be more, not less, intense than that which is oblique and indirect. Thus,

by this denial of ether distinct from matter, the doctrine of Conservation, in its very basis, would be made not only doubtful and unproved, but even impossible.

Fourthly, the doctrine, to meet the facts, requires the existence of a law of repulsion, in some ethereal medium, depending on the distance, and varying far more rapidly than gravity, and also an intermediate law of cohesive attraction, which may be that of matter on ether. Now, Mr. Spencer affirms gravitation to be a necessary result of the laws of space. If so, either a repulsion, or any attraction varying by a higher law than the inverse square, is impossible in the nature of things. For no atoms can attract and repel each other at the same moment, or attract by two different incompatible laws at the same time. How can statements so plainly contradicted by all the facts of science be the basis of new and improved philosophy?

Again, the doctrine implies that every atom is a centre of force, varying ever in its amount, but acting every moment on all other atoms. Yet the paper asserts that matter may impart motion without any force, by its movement alone. Now this is a double contradiction of the doctrine. For, first, it supposes that a moving body can be without any force, which sets aside the Newtonian law, and also every other that satisfies the conditions of the problem. And next, it introduces a new law of force, depending on the speed, not the distance, which is equally fatal to the truth of the theory he undertakes to prove.

But I must draw these remarks to a close. The Conservation of Motion, as a physical theory and hypothesis, does not mean that the total motion of the universe is constant, for it is ever varying, and must ever vary, by any probable laws of force. It does not mean that force is motion, or motion force, for one is the cause, the other its effect. It does not mean that the sum of the forces is constant, for they vary separately as each distance varies, and collectively, as the whole system contracts or expands. It does not mean that their sum is constant, for under many conceivable alternatives both the forces and the motions may increase together. It does not mean that the total of all force, at all conceivable distances, is a constant, measurable quantity, for by the assumed laws this total, in each pair of atoms, and much more in their collective sum, is infinite and immeasurable. It means, really, that the true constitution of matter and ether, the medium of light and electricity, is that of centres of force, which repel more and more, and never touch, and not that of finite, solid atoms, which being impenetrable, not repulsive, would suddenly stop in collision and destroy the opposite motions. As a key to the various modes

of action in lifeless matter I believe the theory to be true, though direct proof of its truth, by strict induction, is far beyond the actual attainments of science. But the conditions it involves, and without which its truth is impossible, seem quite hidden from many of those who are loudest in its praise, since they contradict and deny every one of them in turn. When its claims are carried higher, to bind all nature fast in fate, make prayer unreasonable, responsibility a dream, and the moral government of a Creator and Judge impossible, the folly and self-contradiction are extreme. For the doctrine is not proved at all, except in the region of matter, from which choice and discrimination, pain, pleasure, emotion, duty, faith, love, are wholly absent. And even within its own proper limits, where the eye is not blind, it points clearly and irresistibly to higher truths. Such forces, varying with the distance, cannot act at all without distances assigned to the atoms, and in the law itself there is nothing to assign them. They point upward to the choice of a Supreme Will. And the law itself repeats the same lesson in another form. Whether attractive or repulsive, it loses itself in the infinitude of distance at one extreme, as the atoms diverge, and the infinitude of force at the other, when they coalesce into one. Thus the law loses itself in the mystery of Divine Omnipresence on one side, and on the other, in the abyss of the Divine Omnipotence. It repeats, in humbler tones, and from the lowest platform of science, the lesson which crowns the noble unfoldings of Christian Theology. "For of Him and through Him and to Him are all things, to whom be glory for ever. Amen!"

A vote of thanks was then conveyed to Professor Birks for his able paper.

Mr. C. BROOKE, F.R.S.—Inasmuch as some views put forward in a paper of mine have been alluded to and directly contravened by Professor Birks, I think I may fairly claim the privilege of being the first to make some observations. I am free and happy to say that the main object of Professor Birks's paper—that of confuting the infidel and irreligious tendencies of modern scientific thought—is entirely in harmony with my own views, and with the intention of my paper already referred to; but, inasmuch as I am accused in the paper before us of falling into the very same class of errors which I have imputed to others, I think it but fair that I should be permitted to clear myself if I can. Now, in legitimately attacking a theory, it is of course desirable to represent what it does, and not what it does not mean; but I must express my regret that in this paper I think the doctrine of the conservation of energy is represented to mean a great many things which, so far as I understand it, it does not mean, and was never supposed to mean by any of its advocates. The

length of the paper, and the lateness of the hour, compel me to make my observations as brief as I can, and I will therefore refer, in the order in which they occur, to several points in the paper. I would first make a remark on the following observation contained in the fourth page:—

“Force, by the usual definition, involved in Newton’s first and second axioms, and accepted in all works of exact science, is that which produces or tends to produce or destroy motion.”

Now this is the very definition of force to which I have in my paper distinctly objected. If this be taken as the definition of force, then what occurs on the top of the next page,—

“A moving body does not alter, and cannot be conceived to alter, the state of another, except by the intervention of force,”—

is perfectly true; because if everything that alters the condition of a body with regard to its rest or motion is force, then it must be force that alters the condition of its rest or motion; but if that definition be not tenable, then the observation which is made upon it falls to the ground. Then, in the fifth page, Professor Birks asks:—

“Is the total force, in such a universe, fixed, constant, and invariable? It is one of the simplest truths of dynamics that it varies continually, from hour to hour, from moment to moment.”

Now, what is here meant by the variation of a force, but the variation of its action? Take one example—the force of gravitation. Does any one doubt that the force of gravitation is a constant, invariable force? Is it not a fact that on the very invariability of the force of gravitation the accuracy of all the predicted results of astronomy depends: the truth of all the calculations with regard to the movements of the heavenly bodies,—the exact period of an eclipse or a transit of Venus,—depends on the assumption of the force of gravitation being constant and invariable. How is a force to be measured? I conceive that the only measure we can have of a force, or by which we can compare it with another, is to take its action upon a unit quantity of matter at a unit of distance. If the action of any force upon a unit of matter at a unit of distance be at all times the same, then, I say, the force is invariable. It acts with different degrees at different distances; but that is not an increase or diminution of the force, but of its action according to distance, and these appear to me to be two very different things. Professor Birks says:—

“Let us further take force in its proper sense, just defined, on which the *Principia* and all trains of abstract dynamical reasoning depend. Is the total of force in such a universe fixed, constant, and invariable?”

The force is fixed, constant, and invariable, but the amount of its action will depend upon the nature of the material on which, and the amount of the distance at which, it acts; and therefore Professor Birks’s subsequent remark that force varies continually has no real bearing upon the question. In the next paragraph we find the following passage:—

“Thus momentum, or the mass multiplied by the velocity, is viewed as a kind of variety of force, and *Vis viva*, or living force, is used to express the

amount of motion, as measured by the product of the mass and the square of the velocity."

Now force and momentum appear to me, if they mean anything at all, to mean two totally different things, and therefore I cannot conceive how momentum can be viewed as a kind of force. The latter part of the passage, referring to *Vis viva*, appears to me to be giving a meaning to the word "motion" which it does not bear. As I understand it, motion is nothing more than the act of moving or changing place. If you say a body is in motion, you mean it is changing its position in space; if you say it is not in motion, you mean that it is in the same position that it occupied before, that is relatively; for, of course, everything on the surface of the earth is moving in common with the earth; but we mean motion in relation to the earth. If we say a body is at rest, we mean at rest with regard to the mass of the earth. Therefore we must all bear in mind what is the real distinction between actual and relative motion, and that we are constantly inclined to speak of relative motion, and to give it the name of actual motion. We are inclined to say that any object upon a table is at rest, whereas we know that it is moving round the axis of the earth, and moving together with the earth on its orbit; and if the sun is progressing through space, it is also partaking of that motion. Therefore, to say a body is at rest does not mean that it is occupying the same absolute point of space, but relatively at rest with regard to the objects by which it is surrounded. Then Professor Birks says:—

"Thirdly, it is the constancy of each force in any system of forces; for 'to conceive one or more of the forces to have increased or diminished is conceiving that force is not persistent' (F.P., p. 193, § 53). Fourthly, it is the constant variation of all forces, attractive or repulsive, by the law of the inverse square."

A force does vary. The force of gravitation is a constant force: its action depends on the inverse square of the distance of the body acted upon by it; but the force itself does not vary. Here, I think, is an instance of a force being confounded with its action. Then Professor Birks says:—

"Now let two bodies act on each other by a law of force, which depends on the inverse distance, and their motion be measured by the square of the velocity."

But is their motion to be measured by the square of the velocity? Supposing one body moving at the rate of one foot per second, and another at the rate of two feet per second, if I ask what is the relation between their motions, any one will tell me the motion in one case is double that of the other; but according to this we should say one is four times the other. If motion be a change of place, it can only be measured by the amount of that change; and if one body travels at the rate of one foot in a second, and the other at the rate of two feet in the same time, it is quite clear that the motion of the one body is double the motion of the other. But in this case I think motion is confused with energy. Then, again, Professor Birks says:—

"The old name of the motion, thus increased or diminished, is *Vis viva*, and the new one, not at all clearer, Kinetic Energy."

Now I grant that Kinetic Energy and *Vis viva* have the same meaning ; but motion is neither the one nor the other. It is perfectly true that if you have two equal bodies moving, one at the rate of one foot in a second, and the other at the rate of two feet in a second, the one moving two feet will have four times the Kinetic Energy or *Vis viva* of the other ; but that is a different thing from having four times the motion of the other. Motion appears to me to have a meaning perfectly distinct from that of Kinetic Energy, or *Vis viva*. Professor Birks says :—

“Let us admit the power of this name, Energy, to fuse into one total unchangeable and indestructible, these unlike elements, Potential Energy, or force, and Kinetic Energy, or motion.”

Now, potential energy is not force, and force is not potential energy. Kinetic energy is not motion, and motion is not kinetic energy. If you assume that potential energy and force are interchangeable terms, and that kinetic energy and motion are interchangeable terms, you get into a confusion from which it is very easy to show contradictions ; but as a matter of fact they are totally different things, and I cannot illustrate this more forcibly to your minds than by giving an example. Suppose I have two balls of equal size in my hand, and let them drop together ; they reach the earth at the same instant of time, if they are dropped at the same instant. We should say that those balls had the same motion. They reach the earth at the same instant, travelling side by side, in exactly the same time. But let us vary the experiment, and put a sheet of glass on the ground under my hand. Let me drop one ball, and it rebounds harmlessly ; then let me drop the other, and it breaks the glass. That is not the effect of the motion, but of the kinetic energy which the balls respectively possessed : the first happened to be a ball of soft wood, and the other a ball of iron or lead. Now, although those balls may have had the same motion, they possess very different amounts of kinetic energy, or, according to my own definition, a very different power of doing work. One has power of doing work in smashing the glass which the other has not, and that depends on the amount of energy or work which it has acquired. Energy—*ἐνέργεια*—simply means work, and the amount of work in each of these bodies is measured by the mass multiplied by the square of its velocity, and inasmuch as there is much more mass in the leaden than in the wooden ball, it has in the same proportion so much more kinetic energy, and does work which the wooden ball is incapable of. This, I think, points out a clear mental conception of the difference between motion and energy. Motion, as I conceive it, is one thing ; energy is a totally distinct thing. Professor Birks, at page 291, gives us a humorous illustration of “kinetic energy” and “potential energy” as applied to street population. He will forgive me if I quote in reply the saying of a German author :—“If wisdom be attired in the parti-coloured garb of folly, for the purpose of exciting ridicule, the ridicule is due to the garb and not to the wearer.” Then Professor Birks says :—

“Fallacy the third. This total Energy, said to be invariable, is the sum of the actual motions.”

Energy is no sum of motions. My own opinion on the "fourth fallacy" is that the author has confounded motions with forces, and I think that will explain a great deal of what he has stated in the course of his paper. Then he says :—

"By the laws of force, however, so far as science has detected or conjectured them, the force depends on the inverse distance, and will be infinite when two particles touch or coalesce";

and some subsequent argument is founded on the summation of these infinities. But so far as we know, it is impossible for two particles to touch or coalesce. The opinion of Newton was that the distance between continuous particles is indefinitely great compared with the magnitude of the particles themselves. We know there is no limit to the contraction of most bodies by cold, and we can only suppose the particles come into actual contact when we reach absolute zero of temperature—a degree of cold or negation of heat which is utterly unattainable, and which probably never did or will exist in nature. It therefore appears to me that any argument founded on the introduction of infinite qualities, which must necessarily be introduced if the particles touch, falls to the ground, because it cannot possibly be assumed. Then Professor Birks says :—

"Contradiction the second. The doctrine assumes that motion or Kinetic Energy is the same identical thing or quality with Potential Energy, because of a numerical equivalence, when reckoned in one especial way. But this is wholly untrue. A rectangle, when its breadth is the unit of distance, has its length and its area or surface expressed by the same number. But a length and a surface are not on that account the same."

In the first place I maintain that motion and kinetic energy are two totally different things, and any contradiction founded on the assumption that they are identical falls to the ground, because they are not synonymous terms. Of course, as the author says, a length and a surface are not the same; but that has nothing to do with the question—with a rectangle, the width of which is the unit of length, the length of the rectangle will be the length of the other side, whether it be longer or shorter. But what does that mean? It only means that there are as many units of length on the other side of the rectangle, as there are units of area in its surface. In a rectangle which is one inch wide and five inches long, the length of the rectangle will be five inches and the area five square inches. These are merely the numerical equivalents or the co-efficients in the two cases, but no one would infer from that that length and surface mean the same thing, or can be added together. Then again Professor Birks says :—

"A cannon-ball is shot upward at the rate of a thousand feet a second. The doctrine affirms this speed of motion to be the very same thing with the place of that ball on the top of a mountain three miles high."

This is certainly not affirmed by any doctrine with which I am acquainted. I do not know where Professor Birks will find any such argument used by any writer on the subject: they are two totally different things, having no relation to each other. The doctrine, as I and its supporters understand it, is that if a ball is shot up at the rate of 1,000 feet in a

second, it will continue rising until the attraction of gravitation which is continually pulling it downwards and diminishing its progress upwards, at last arrests it, and its velocity upwards becomes nothing; it comes to rest at a certain point. If a shelf be there placed under it to support it, the ball is then said to have acquired a certain amount of potential energy, or energy of position. What does that mean? It means simply that if it be allowed to descend again from that point to the earth, it will in its descent acquire exactly the same amount of energy which was expended in propelling it, and that is a fact which no experiment or proof in any way can controvert. Again:—

“Contradiction the third. Motion, by the theory, may be transferred from one body to another, remaining the same motion still. It may reverse its direction, and be the same motion, if its rate be the same.”

Certainly not; no one can say that motion in one direction is the same as motion in an opposite direction. I do not know any author who has ever stated that, and it seems to me to arise from a misapprehension of the theory which the author is endeavouring to combat. Then, in another passage, Professor Birks has called potential energy the amount of force which would be expended in bringing a body from an infinite distance to the place it occupies. And he goes on to say:—

“Contradiction the fifth. The Potential Energy supplies another element of confused thought and metaphysical incongruity, as striking as the last.”

If the definition he has already given be correct, it is true that there is an element of confused thought and metaphysical incongruity, but that I fear is the fault of his definition of potential energy. Then we have this passage:—

“But how can we conceive a particle of motion, which is not a thing that moves, but an abstract quality or relation, pushing or pulling another particle of the same force?”

We cannot, of course, conceive a particle of motion. Motion is a change of place, and a particle of motion has no meaning. No one that I know of ever attempted the use of these expressions.

Professor BIRKS.—You will find them used both by Mill and Spencer.

Mr. BROOKE.—Then we have this passage:—

“Three fundamental errors have already been pointed out, which contradict the first principles of clear dynamical reasoning: that statical pressures are not forces, that friction is not a force, and that one body in motion can move another without the intervention of any force whatever.”

I would hardly go into that, but if the definition which Professor Birks has given us is to be generally accepted, then anything that changes the conditions of a body is force. Certainly friction is a force. This table is a force, as it arrests the falling of this book to the ground. But it appears to me that this involves a contradiction in terms which is unsuitable to the real meaning of the word, which I think had much better be considered and defined in the way that I have elsewhere defined it. I will now only make one or two further remarks. There is one point personally affecting myself

which I am bound to refer to. Professor Birks, in criticising my paper on Force and Energy, says :—

“ Still further, in §§ 24, 25, light and heat are said to be accurately defined as ‘ a very brisk agitation of the insensible parts of the object.’ Yet in § 29 we read that they ‘ have frequently been illogically designated as “ modes of motion ” by able physicists,’ and this ‘ has led them into a hopeless confusion of the terms, force, energy, and motion.’ But a very brisk agitation is certainly a mode of motion, so that the paper is a fresh instance of that confusion of which its writer justly complains.”

Now, I fear Professor Birks has overlooked my argument. I will read one of the paragraphs in my paper which is referred to, and leave it to speak for itself. I say at the close of the 23rd section of my paper “ John Locke writes :—‘ Heat is a very brisk agitation of the insensible parts of the object, which produces in us that sensation from whence we denominate the object “ hot ” ; so what in our own sensation is heat, in the object is nothing but motion.’ It would be, perhaps, still more precise to say, ‘ heat arises from,’ &c., in place of ‘ heat is,’ &c., because the latter part of the definition states heat to be, not the motion, but the perception of it.” Then I go on, in my 24th section, to say :—“ Precisely the same definition will serve equally for light, if ‘ light ’ be substituted for ‘ heat,’ and ‘ luminous ’ for ‘ hot.’ It would then read thus :—‘ Light is a very brisk agitation of the insensible parts of the object which produces in us that sensation from whence we denominate the object luminous ; so that what in our sensation is light, in the object is nothing but motion.’ ” I therefore maintain, in the last few lines of my 23rd section, and pointedly state that heat and light are not to be accurately defined as a very brisk agitation of the insensible parts of the object, but as the result of that brisk agitation. To say that one thing is another, and to say that one thing is the result of another, are certainly very different statements. What I have said will show that he speaks of me as having made the very error which I have imputed to others. If the definition of force which I have given be taken as the true definition, I think that that, with what I have said in my paper, and with the illustrations which I have given to-night, will establish the point that the conception of force is a distinct mental conception, apart from the conception of its operation. You may have a magnet, and you may have a mental conception of the force situated in the pole of that magnet ; and that conception is quite independent of any action of that force. You may have iron, which the magnet attracts, or bismuth, which it repels, or the similar pole of another magnet, which it repels ; but the idea of the force existing in the magnet is to me entirely independent of its exercise upon another body. So in the same way the conception of the existence of a force appears to me totally different from the conception of the action which it produces. There is only one other point I want to refer to, and I certainly must admit it was an oversight on my part. Professor Birks refers to my paper as having spoken of force producing, and being the cause of that action between particles or masses of matter by which they are drawn together and

separated from each other. He then refers to a sentence in the discussion at the end of the paper, in which it appears that I spoke of force as being an attraction or a repulsion—a push or a pull. Now what I meant to say, and what I thought I said, was, that force was attractive or repulsive, and that it produces either a push or a pull; that is to say, that a push or a pull is the result of a force, but is not a force itself. If I did say what is attributed to me in the report, it was an oversight. I am sorry that I have detained you so long; but I felt, in justice to myself, that I was bound to show I was not guilty of the errors imputed to me. (Cheers.)

Mr. E. PICKERSGILL.—I should like to refer to a few particulars in which it appears to me that Professor Birks has been a little unjust to the author of *First Principles*, who is the chief exponent of those Neo-Lucretian views which the Professor has attacked. In the first place, with regard to that expression, “the persistence of force,” which Professor Tyndall and Mr. Herbert Spencer have used—

Professor BIRKS.—And Professor Huxley.

Mr. PICKERSGILL.—It appears to me that, in being so severe upon that expression (he says it reminds him of the proverbial broomstick), Professor Birks has confined himself to that position of orthodoxy which is certainly the position of myself, and which, I suppose, is the position of the majority in this room. But it seems to me that he ought, for the time at least, to have transferred himself into the position of Professor Tyndall and Mr. Herbert Spencer. “The persistence of force” may be a very terrible expression to orthodox thinkers, but to thinkers who are not orthodox—such as those to whom I have alluded—I do not see that it is terrible at all, and it appears to express very fairly that idea which Herbert Spencer intends in his *First Principles*. Then I take this passage from the paper:—

“Is the total of force, in such a universe, fixed, constant, and invariable? It is one of the simplest truths of dynamics that it varies continually, from hour to hour, from moment to moment. If attractive forces are in excess, it increases in a condensing system, and decreases with dilatation.”

Let us consider the conditions of the material world as proposed in this paper. It consists of a vast—not infinite—number of atoms, between some of which there is exercised an attractive force, and between some of which there is exercised a repulsive force. Now, suppose the attractive forces are in excess, and that the system is condensed. Now, it is perfectly true that, upon the condensation of that system, the total sum of attractive forces will be increased; but is it not equally true that the total sum of the repulsive forces will be diminished, and therefore that the difference between them, *i. e.* the net total of force, may remain precisely as it was before the condensation? There are one or two other points to which I should like to call your attention. Professor Birks says:—

“Yet we are taught that this wholly unknown Being, whether he has a will to do it or not, cannot destroy one particle of this wholly unknown and unknowable thing or quality, which we call Force or Energy.”

Now, Mr. Herbert Spencer does not suppose the existence of an un-

known being, *independent of that force*, as Professor Birks has represented in the foregoing quotation. Force itself is the divinity which these philosophers would wish to seat upon the throne of the universe. Mr. Herbert Spencer does not assume, first, an unknown being corresponding to God, and then the force, but that force itself is the unknown being, the God, the Divinity of the universe. Lastly, the Professor gives us an illustration to which attention has been already called.

“A cannon-ball is shot upward at the rate of a thousand feet a second. The doctrine affirms this speed of motion to be the very same thing with the place of that ball on the top of a mountain three miles high.”

Mr. Brooke took exception to that statement: I am sorry that I did not quite follow him in his observations, but the illustration, as it appears to me, in order to be quite consistent with what has gone before ought to be this:—Suppose a cricket-ball is thrown up by a human arm at the rate of 300 feet a second, then the doctrine affirms that that speed or motion is the same thing with the force in the arm which threw up the ball. Before I sit down I should like to refer to one aspect of the question in regard to which I quite agree with Professor Birks, namely: Mr. Herbert Spencer's position that “the persistence of force” is an *ultimate* idea of the human mind. In fact, Mr. Spencer wishes to place us, in regard to that idea, precisely in the position of Molière's Monsieur Jourdain, who, without knowing it, had all his life been talking prose. We, in the same way, without knowing it, have always been believing in the indestructibility of force. That appears to me to be a most dangerous position to assume. As Professor Birks has most ably put before you, it would involve most dangerous conclusions, and would provide a way for the introduction of most crude and mischievous principles. You first assume that a thing is true, and having shown that it cannot be proved *à posteriori*, you further assume that it is *à priori* truth—a truth which has always been believed by men, and which cannot possibly be disbelieved. If you admit that principle it will be obvious to every one that you admit a principle which might have most dangerous results.

The Rev. S. WAINWRIGHT, D.D.—Had the last speaker not been a new member, he would have known that we are not in the habit of talking of what is orthodox or heterodox, but that the one aim of our discussions is to sift each question brought before us, and find out the truth. (Hear, hear.) On this ground I am bold enough to take my stand by the author of the paper, and without doing what I am sure he would not wish me to do—attempting to defend every line and letter that he has written. I say he has gratified us with an admirable argument, and ably sustained it. (Hear, hear.) At the same time I do not desire to oppose Mr. Brooke. Professor Birks and Mr. Brooke have said very much the same thing on a great many points. Professor Birks says very distinctly that force and motion are definite things and can be defined. Mr. Brooke says exactly the same thing. Mr. Brooke says motion is one thing, energy is another—that is exactly what Professor Birks has said. Professor Birks says that

force and motion are definite terms which he used in a definite sense, but he complains of the confusion attaching to the term "energy," and incidental to the use of that *tertium quid*. Another point on which they are at one seemed to be urged against Professor Birks: Mr. Brooke asks, "How can you conceive a particle of motion?" But he has fastened upon one part of a passage and left the rest; for Professor Birks himself says, "How can there be such a thing as a particle of motion?" The passage runs,

"What other power compels the blind Titan to weary itself in these ceaseless transmigrations? We can easily conceive one body, endowed with active power, pushing or pulling, seeking or avoiding, another. But how can we conceive a particle of motion, which is not a thing that moves, but an abstract quality or relation, pushing or pulling another particle of the same force."

I think the difference between Mr. Brooke and the Professor is divergence rather than antagonism. No doubt there are some points of antagonism, but I think it is in the interest of the pursuit of truths that we have not yet reached, that we should minimise rather than magnify divergencies on subsidiary points. Let me give two illustrations of what I mean. I cannot quite take up arms against this paper, and condemn it for being too clear. I remember the remarks of Archbishop Whately. Mr. Brooke gives us a German apophthegm, but I do not think it applies to Professor Birks and his "garb of folly." He does what Socrates did in his day, and tries to take the power from those who make the worse appear the better reason. Whately talked of a certain class of minds who never were satisfied with anything sufficiently clear to enable them to see to the bottom; only stir up the mud, and then they would cry, "How deep that is!" I thank the man who lets the sediment go away and gives the clear stream, and therefore I am obliged to Professor Birks. If the doctrine of the persistence of force is as I understand it, and as I know it to be expressed by Professor Huxley and Dr. Tyndall, it is the doctrine of the broomstick without the possibility of the existence of another power outside to interfere with it. That is the question at issue, and we ought not to allow such a doctrine to take a place to which it has no right, or to usurp a place as an established truth, before it has given credentials and stood its ground successfully. There is a German author who gives us an illustration on another subject. He says, "You talk of Providence; and of Divine government, and Divine action, and so on. Will you tell me what room there is for it in the world? You are on the sea-shore, where there is a particular grain of sand ten or fifteen feet from high water-mark. Perhaps Divine Providence, you think, might have taken that grain of sand and let it be half an inch nearer or further from high water-mark. Do you know what it would involve if you prayed to God or to Providence for such a result, and your prayer was answered? That particular grain of sand is where it is because the force of the waves has been exact and definite, and that has been the result of the force of certain storms that have raged, and they have depended upon climatal conditions and atmospheric changes, and they in turn have depended on the nature of the

soil and the atmosphere, and the attraction of mountain ranges and currents. But to have altered these climatal conditions would have involved pestilence and the slaughter of millions of mankind ; and so you must have had a reconstitution of the universe, a different shape for the continents, and a different direction for the currents, in order to get that particular grain of sand half an inch higher or lower." Now that is the doctrine of the broomstick pure and simple. (Laughter.) Yet one of the most distinguished men of our time—for I do not hesitate to say that I revere the name of Charles Kingsley—has thought it right to say that to pray for fair weather was, in fact, to pray that God would alter the shape of the continents, and the size of the solar and lunar bodies, and the rate at which they spin round. Notwithstanding my reverence for the man, I am bound to say that he said that as a Christian preacher. I have taken that case of the grain of sand for this reason : I say that what you are saying might be true in a conceivable world, where there was no such thing as another source of force that you have left out of the calculation. But there is another force—that of volition. There is a physical force, but there is also a primary force of volition, which makes the physical force obedient to it. We live in a world where there are not merely physical forces which act molecularly, but there are also chemical forces, and other forces entirely apart and distinct from chemical, physical, and molecular forces. Volition is a force. Human volition can change, and has changed, the destiny of nations, tunnelled the Alps, and bridged the seas ; and if it has transformed so many things, it is in the highest degree unphilosophical to say that you can have a world of volition without a primary volition, just as it would be unphilosophical to say you can have a force of gravitation, and yet deny the existence of a great reservoir of force of which that force of gravitation is one single specimen. Dr. Tyndall says the facts of religion are to him as certain as the facts of physics ; and when he has said that, he has given us all we ask for, and there will continue to be more things in volition than are dreamed of in his philosophy, until he has admitted volitional, emotional, intelligent forces, adequate to the facts of the case. (Cheers.)

Mr. C. R. MACCLYMONT.—I do not rise to propose any fresh points of controversy on this question. There seems to me, however, a broader view of the relation of physical science to theology, suggested by the discussion, which I wish to direct the attention of the meeting to for a moment. Though Professor Tyndall has undoubtedly a certain faculty of stating in popular fashion the mere superficial aspects of the questions with which he deals, it seems to me a pity that he should be selected as the typical man of science, in discussions such as these ; for undoubtedly he is the weakest of the band whose conclusions theologians at the present day feel called upon chiefly to protest against. But is it true that the conclusions of science which we have heard discussed to-night are really antagonistic to the doctrines of sound orthodoxy ? I continue to think that such doctrines as those of the Conservation of Energy, or of the Origin of Species, when examined in the true spirit of science, are not only not opposed, but are in strict agreement with

the teaching of the old authorities of the Church. These doctrines may indeed be stated offensively, as in the flimsy phrasing of one like Tyndall. But even in his writing—as in the article on prayer, of which we have heard so much—we see how the larger conclusions of science are gradually approximating in their result to reassertion of the true relations of Deity to the World and Man, as we have them in Augustine and others of like authority in the Church. There is no real conflict between the highest science and the widest orthodoxy. It is only when the theologian fails in faith or charity, and the man of science fails in knowledge or reverence, that the conflict seems to arise.*

Professor BIRKS.—It is very difficult for me, at this hour, to reply to the

* Mr. J. E. Howard, F.R.S., remarks as follows upon the persistence of Force, or the conservation of Energy:—Is it not probable that the true solution of this question is one which involves a much more fundamental agreement than is admitted on either side? On the part of our “thinkers,” for whom Mr. Herbert Spencer may stand as the mouthpiece, we find it to be admitted that the result of their deepest researches into the nature of things involves this conclusion, that the forces of nature, however largely convertible the one into the other, are not capable of being destroyed; and further, that the storehouse of force in the universe is inconceivable and inexhaustible, and apparently illimitable. Underlying all the forces of the universe, philosophy requires one permanent, inexhaustible, continually immanent energy, which cannot be conceived to abate for a single moment one fraction of its potency, without the ruin of the whole. The philosophical name of this first cause is FORCE. The Scripture likewise informs us of power everywhere existing, either potential or actual. The term by which this is designated is *δύναμις*; and when this power goes forth in action, it is termed energy—*ἐνέργεια* (see Eph. i. 19, &c.). All things are upheld by the word of His power, which is continually exerted in the maintenance of the creation. This power is constantly ascribed to God, (Matt. xxvi. 64, &c.) and even identified with Him, as in the passage to which I have referred; and as this *δύναμις* is all treasured up in the Almighty, He is called “the blessed and only Potentate (*δυνάστης*). The potential energy of His power has been shown in the raising up of Christ from the dead, which foreshadows and involves (1 Cor. xv.) the dead being raised by the putting forth of power which is yet in abeyance. This power of God can never suffer the smallest imperfection or diminution. It is ever new and ever young. Therefore we read in the New Testament: “I am Alpha and Omega, the beginning and the ending, saith the Lord, which is, and which was, and which is to come, the Almighty.” In the Old Testament we have the same truth, set forth in the very name Jehovah; and He is constantly represented as everywhere present and acting, not only amongst His people, but in nature. Thus, in Psalm civ., the operations of nature are directly ascribed to Jehovah; and where we see the laws of nature, the inspired Hebrew poet saw the God of these laws; instead of praising Sabaoth, he praised the Lord of Sabaoth. So that the believer in revelation comes at once to the perception of force in nature; but this force, potential or actual, is an attribute of God. Is not the advantage of clearness of definition very much on the side of Scripture? and is it not an immense relief to the mind to rest upon a loving, heavenly Father, rather than to feel bound to the chariot-wheels of inexorable fate?

The philosopher may worship FORCE, but we worship GOD.

somewhat discursive remarks which have been made upon my paper. But I must claim, in fairness, to offer some explanations, because of the unusual form the discussion has assumed. Mr. Brooke has occupied nearly the time of a second paper in opposition to my remarks. My paper was prepared before I knew that Mr. Brooke had read one on a kindred subject, and mainly in reference to Mr. Herbert Spencer's *First Principles* and Dr. Tyndall's recent address. In fact, it continued a line of thought in a paper read at the Brighton Congress. When the Honorary Secretary sent me Mr. Brooke's paper, I could not avoid making some remarks upon it, since I differed from it so widely. My criticisms upon it were quite supplementary, and almost unavoidable, and I am sorry this part of the subject should have this evening had an unnecessary prominence. I stated very clearly that Mr. Brooke's views were in entire contrast with those of Mr. Spencer and Dr. Tyndall on the moral aspect of the question. But we are here to maintain truth honestly, without respect of persons, and cannot safely disguise our conviction that certain views are wholly false, even though they are shared by some friends who are on our side in the main controversy. My chief object was to show that Mr. Spencer and Dr. Tyndall are not only wrong in their application of their theory of force or energy to moral questions, but in their conception of the principle itself, and that their view, when closely examined, is stored and steeped with logical contradictions. Now since Mr. Brooke adopts their doctrine, in words, as a grand recent discovery of science, and then discards Newton's definition of force, and frames a new one of energy in order to remove the difficulties which it involves at every turn, it was essential for me briefly to point out what I conceive to be such fundamental errors, and so fatal to the possibility of a clear conception of my argument. One first and main question between us is whether we are bound to use the fundamental terms of science in their usual sense, accepted by the standard authorities, or may vary them at our own pleasure, and adopt wholly different ones in their stead? The definition of force which I used is that of Newton and all his successors. Mr. Brooke himself quotes half a dozen leading authors who agree in it, but only to charge them with having gone wrong together. He distinguishes force from the action of force, and makes the contrast of force and energy to be, that the first is potential, and the second actual. But the force of Newton's *Principia* and all dynamical works of authority is actual force, measured by its present actual effect in change of motion. And the only energy which is force in any sense is called "potential energy," as its very definition, in Dr. Thomson and Tait's treatise, and similar works, where the conservation of energy receives scientific treatment. So that Mr. Brooke exactly inverts the relation between them by the usual and accepted definitions. The result of such an arbitrary change and reversal must be interminable confusion of speech and thought. His force is the mere possibility of force to be exercised hereafter, and his action of force, or energy, is the force, in Newton's sense and that of all dynamical treatises, which exists and acts at any particular moment. Now if we include all the possibilities of force, past, present, and future, under the name of

force, it is a very easy and simple inference that its total is invariable. But to speak of this as a great scientific discovery is a mere illusion. Mr. Brooke has charged one passage of my paper with misplaced ridicule. It is really nothing more than an exact and logical description of the error involved in Mr. Spencer's theory. An eternity of possible future actions of force is summed up into a total; and then, having replaced present, actual force, by a formula, which includes all the past, present and future, the unchangeableness of this total, from time to time, is taken for some great discovery. I should be sorry to appear to speak with contempt of any person of high reputation. But there is a great temptation, in these days, where there is general reputation for ability, to disguise and overlook the most serious logical contradictions, and reviving the principle of human authority, to apply it to these newest names in sciences, so as to create a real danger and stumbling-block to the faith of Christians. Mr. H. Spencer, no doubt, is a person of great ability and intelligence; but when I examine his work closely, I know of none which abounds more in direct and fatal contradictions. I believe that I have done him no injustice in my remarks. He has been seeking to build up a philosophy which treats theology as an impossible science, and gets rid of the Great First Cause, the God of the Bible, altogether. But the basis of the whole argument lies in proving, first, that the principles of religion and science are alike inscrutable, and then in dismissing theology as hopelessly dark and blind, and treating science as an open field for fresh discoveries. If the inscrutable nature of its first principle is a reason why nothing can be known in religion, the argument will equally prove that nothing can be known in science. I believe, with him, that much is known, and can be known, in physical science, though all its fundamental ideas lose themselves in mystery. And in like manner we can know, and ought to know, much concerning the character and works of the Supreme Creator, while we confess, with Hooker, and Scripture itself, that "His nature is unsearchable, His greatness beyond our capacity and reach." My object has been to show that Mr. Spencer's First Principles do not give us any clear conception of his so-called Persistence of Force, but that he contradicts himself at every step, when he would explain his own meaning. As to the conservation of energy, that is, of *Vis viva*, I deny altogether that it is an *à priori* truth. It is the result of a special dynamical hypothesis, which might or might not be confirmed by inductive observation. We have no right beforehand to assume its truth as self-evident. It is a doctrine which Newton did not hold, but its reverse. When imposed upon our faith, not as a probable deduction from the facts of science within certain defined limits of mere mechanical change, but as an *à priori* truth, which is to sweep away all religious faith as superstitious error, and put the universe under the dominion of a blind Fate, we are bound to oppose it with all our might, and show the gigantic delusion and falsehood on which it rests. The theory, in the shape it has latterly assumed, is false to the best interests and true dignity of man in the present life, as well as to the hopes of the life to come.

I cannot, at this hour, reply in detail to Mr. Brooke's strictures, or those of one or two other speakers, but I have heard nothing which convicts me of any mistake, or which I do not feel that I could easily answer, and prove the correctness of my own statement, and the error of the counter-statement, did time allow. But a real discussion of the objections I entertain to Mr. Brooke's statement this evening, and his former paper, would require a second paper a full hour in length. The thoughts I have offered are not hastily put together. They are the partial outcome from years of meditation on these subjects. Though no practical experimentalist, I have studied mathematical and physical science with interest from childhood. And I feel that most of those who talk so loudly about the grand discovery, whether they call it Conservation of Force, Persistency of Force, or Conservation of Energy, do not even understand their own meaning; and that all genuine discoveries, even in mere physics, are only steps in an ascending pathway, that must lead careful and thoughtful minds continually upward to the throne of God.

The meeting was then adjourned.

ORDINARY MEETING, FEBRUARY 15, 1875.

THE REV. PREBENDARY ROW, M.A., IN THE CHAIR.

The minutes of the last Meeting were read and confirmed, and the following Elections were announced :—

HONORARY FOREIGN CORRESPONDENT :—Professor K. A. Wurtz, President of the Association of France for the Advancement of Science, Paris.

ASSOCIATES.—Rev. J. Kennedy, D.D., M.A., Stepney Green; Rev. T. Ragg, M.A., Lawley Vicarage; E. R. Gayer, Esq., Tavistock Square; Miss S. Neale, Brighton.

Also the presentation of the following Works to the Library :—

“Proceedings of the Royal Geographical Society,” Part 1, Vol. xix.

From the Society.

“Number.” By Rev. C. Girdlestone.

From the Author.

“Seven Lectures on Scripture and Science,” 2 copies. By
J. E. Howard, Esq., F.R.S.

Ditto.

“Five Important Truths of Scripture.” By C. Darby, Esq.

Ditto.

The following paper was then read by the Author :—