STORED ENERGY

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Sir Ray Lankester, in one of the interesting papers published under the title, "SCIENCE FROM AN EASY CHAIR," complains that "glib writers in various journals" "with a false assumption of knowledge" "pour forth" "twaddle" concerning science. It should be said that he puts twaddle in quotation marks, also, with the parenthesis "(if I may use an expressive term)". May not these "glib" journalists come back with a complaint that "glib" scientists, of high reputation for actual knowledge, do worse, in that they teach "twaddle" to journalists, that is, to people generally who are not specialists in science? Is not *stored energy* an example? It is taught to non-specialists by writers of high scientific reputation.

Energy is an important word in the technical literature of the science of physics. It is treated of as existing in two forms: kinetic and potential. In books written by scientists to attract, or edify, purchasers among the general public, *potential* often approaches in meaning, or is transformed into, *stored*. This meaning has had a curious effect. It has inspired flights of fancy which may, perhaps, be called poetry, in the sense of "imaginative language, or composition, whether expressed rythmically or in prose" (Webster). At the same time it has operated as a warning against venturing upon prosaic data. The following specimens are culled from "NATURE'S MIRACLES" (Gray, 1899), "MATTER AND ENERGY" (Soddy, 1912), "SCIENCE AND MATERIALISM" (Elliott, 1919), "CREATIVE CHEMISTRY" (Slosson, 1920), and "HISTORICAL GEOLOGY" (Schuchert, 1920):

"These great" coal "beds of stored-up sun-energy* * * warm our houses, * drive the machinery of our factories, * send the locomotives flying across the continents and the steamships over the oceans."

"Energy may sleep indefinitely * * *. In the potential form, in coal, it has persisted for untold ages; once released, heat is the sole ultimate product * * *. The power

* Died April 18, 1922.

of sunlight and coal, electric power, water power, winds and tides do the work of the world."

"By burning the coal, the energy which has so long been locked up is given forth afresh in its original form of heat and light."

"All life and all that life accomplishes depend upon the supply of solar energy stored in the food."

In plants "the kinetic energy of sunlight is transformed * * * into the potential chemical energy of * foodstuffs. Animals * * * convert the potential chemical energy of foodstuffs into the kinetic energy of locomotion and other activities."

These flowers of rhetoric are uniformly unaccompanied by a reference to an observation, experiment or line of reasoning on which they are based, nor has diligent search been able to find such in any literature.

It is possible that the primary motor in all this is the phrase *conservation of energy*. We owe the phrase to a translator. Is it not an instance of unhappy scientific nomenclature? By those who are appropriately educated it is understood as the technical name of a transcendent generalization regarding the physics of nature. But if the phrase should happen to be without illuminating context, when seen for the first time by one not grounded in physics, he would be likely to feel the need of a dictionary, unless diverted by the fancy that it was from an advertisement of a patent medicine held out as preservative of human vigor. He might not take the phrase in a scientific sense, because of the idea that conservation implies design, which, as controlling nature, however religiously believed in, is not within the present reach of science proper.

But Conservation seems less questionable than Energy. "Capacity for performing work" (Webster) fails to satisfy. A recent translator makes Arrhenius say: "Everybody understands what is meant by energy." What Arrhenius might have said if writing in English, is unprofitable conjecture. Men of Science use English expressions such as these: "All forms of energy may be regarded as motion"; "Energy is motion"; The princi-

ple of conservation of energy means that the total amount of "motion" in the universe, or system, "remains ever the same." But a little further reading shows that the meaning is not settled by such expressions. The same book reads: "All forms of energy may be regarded as motion", and there is a "species of energy, named potential energy, in which nothing is moving." The Century Dictionary defines kinetic energy as "energy in the form of motion", and potential energy as "energy existing in a positional form, not as motion".

The most universal illustration of potential energy is a raised weight. The reader may happen to have seen the quotation from Crabb, in the New Revised Encyclopaedic Dictionary: "With energy is connected the idea of activity." If so, he will be sure to ask himself what the activity is doing in the weight while remaining raised, and will be disappointed by not being able to find in the book which gave the illustration, or in any other, either an answer—which perhaps he would not expect—or so much as an intimation that such a question might arise.

Another frequent illustration of potential energy is a coiled watch spring. It is familiar knowledge that if a spring is of gas or rubber, heat is developed in the compression and absorbed upon the release. The reader who has no laboratory, but only books, would be much better satisfied with the illustration if it were accompanied by information as to whether similar heat phenomena attend the use of a metallic spring; also whether, in either case, the heat is adequate to the work. But nowhere is this question referred to.

Conservation of energy is the technical name of the generalization, or principle, that the amount of energy in an isolated system remains the same, that is, never changes in quantity. Carl Snyder ("The World Machine," 1907) says that "gravitation is a standing negation of such a concept". The raised weight illustration certainly induces the question: "Where does gravitation come in?" And if potential energy does not exist "as motion", the question arises whether a clear concept of potential energy can be consistent with an equally clear concept of the conservation of energy. The phrase *per-*

petual motion would seem to be one that "everybody" would understand more easily than *conservation of energy*. It certainly would have been less likely to result in the difficulties attending *kinetic* and *potential*. It has been buried in derision, however, because connoting a machine designed to thwart a fundamental method of nature. But when used so as to include the smallest particles, as well as masses, it cannot be negatived—unless by gravitation, the nature of which, though the subject of a great amount of speculation, remains as much a mystery as ever. Professor Tyndall's description of heat as a "mode of motion" seems better adapted to a clear concept than the modern expression "form of energy".

Exception is not taken to the term *potential energy* in a school book. The pupil who really cares will become scholar enough to understand. The objection is only to its use without the support of explanation or reference in books intended for the general public. It seems to be responsible for *stored energy*. Possibly, also, it may mislead some who are educated in branches of science that do not involve general physics. An eminent, and genuinely scientific author, in such a branch, published the following:

"In animals the final products of broken down protoplasm are carbon dioxide, water, and a nitrogenous substance called urea. These products are called excretory products. The animal machine is unable to utilize *the energy which exists in the form of potential energy* in these substances, and they are removed from the body." (Italics mine.)

The italicized words are unnecessary. They are of the type termed, in legal phraseology, *obiter*. It was suggested to the author that they be omitted from later editions. They reappeared, however, though, to save his life, he could not have proved them, nor cited anything put forth as proof.

Stored energy is the present subject. By its mention the writer is forcibly reminded of the memorable words of the famous philosopher, Mrs. Prig: "I don't believe there's no sich a person."

As the quotations indicate, carbon (in fuel or food) is the leading illustration of stored energy. The quotation of the powers that "do the work of the world" is from so prominent an author in the literature of science as Professor Soddy. Please observe that coal is listed and oxygen not listed. Then perform the concrete experiment. Perhaps you can do so well enough in your mind. It has been performed countless millions of times by an ordinary fire, and thousands of times in the laboratory. The chemistry is elementary. Compound (approximately) 12 weight units of carbon, ordinarily a solid, possessing no readily perceptible activity and incapable of combination without the application of external heat, with 32 like units of the most universally active substance known, oxygen, a gas, capable of combination whether cold or hot, and the result is heat and light and 44 units of a substance more obviously active than solid carbon and less obviously so than oxygen gas. The inference requisite to sustain the illustration is that the motion, or energy, manifested by the heat and light had, immediately before, been in the carbon and not in the oxygen. "Can you beat it?" Please pardon the slang.

The chemical weight units are of such class that commercial weights may be substituted, so that when you burn twelve tons of coal, or rather, of carbon in coal (plus the weight of the ashes, moisture and other irrelevant ingredients), you burn or consume thirty-two tons of oxygen, and besides the heat you were after, you produce forty-four tons of carbon dioxide, that goes up the chimney. The light that is also produced is in the same category as the heat, and need not be considered separately.

Carbon, in wood or coal, has the appearance of a solid possessing no life that can be detected at the woodpile or coal bin. Oxygen, on the other hand, is a gas, which has life that manifests itself by keeping us alive. Moreover, it is, metaphorically, an all-devourer. By devouring carbon it makes carbon dioxide, by devouring hydrogen it has made all the water of the earth, by devouring silicon, etc., all the granite, by devouring iron all the rust, or iron oxide ore, and, by devouring other kinds of matter,

numerous other familiar substances. The compound, carbon dioxide, possesses little or no such life, and is well known to be as certain as water to drown out the life of an animal or fire that is completely immersed in it.

The purpose for which an ordinary fire is built is to produce a more desirable thing than carbon dioxide, namely, heat, which is described by one of the most eminent scientists of history as a "mode of motion". Can a person of "horse sense", without more evidence than the mere reputation, for science, of the writer who tells us of energy "stored-up" or "sleeping" or "locked up" in coal, believe for a moment that the heat of the fire comes from the carbon, and that the oxygen may be ignored? Can it be believed that such writer is not giving us "twaddle"?

"SOLIDIFIED SUNSHINE" is the title of a chapter in a recent and most interesting book from which one of the above quotations was taken. The modest and straightforward character of the book as a whole will banish any suspicion that this title was chosen because

> "When fiction rises pleasing to the eye Men will believe"

Sir Ray Lankester says (Second Series, 1912) that "science takes no heed of empty assertions unaccompanied by evidence which can be weighed and measured." Might he not have added "or common sense" to "science", or, at least, the common sense that is so fortunate as to be supplemented by sufficient education to enjoy scientific literature? But his remark, as made, implies that if the Master of Science, and Ph. D., who gave us "Solidified Sunshine", had obtained that idealism from a friend, he would have asked the friend, in substance: "How did you find out that sunshine, which includes heat, has taken a solidified, rather than a gaseous form, notwithstanding the familiar fact that the application of heat commonly tends to the production of the more tenuous form of matter?" A Master of Science will not be belittled by crediting his reader with enough mentality to recognize such "empty assertions", and to take no

heed of them unless the evidence is found in literature more complimentary to the reader.

The literature above quoted has been written for the general reader. One of the books expressly says so, on its title page. If the general reader is to be fed upon imagination, why not give him something like this? —

Oxygen is the most abundant terrestrial substance known. It is also the most important to our lives, if it is logical to compare the importance of essentials. Its importance is certainly the most obvious. That it is the breath of life is known to everyone whose education has progressed as far as the word oxygen. It supplies the warmth and movement of our bodies. It heats the fire that cooks a meal, warms a dwelling or actuates a boiler. The progress and noise of a railroad train are but other modes of a motion of molecule, atom, electron or something still nearer the infinitesimal, that, shortly before, was going on with inconceivable speed, but silently, invisibly, impalpably, in the oxygen of the air about our heads.

In the animal processes carbon is the chief discard or waste. Oxygen is inhaled, picks up the carbon, and goes out with it. Then, with its load, the oxygen is wafted by atmospheric currents to a contact, at the appropriate time, with a trap which nature operates intermittently in green foliage. There the carbon is caught, and the oxygen, probably aided by an impetus from the sun, flies away to be again wafted by atmospheric currents to within the reach of the breathing of an animal that has eaten the carbon secreted by a leaf, when the cycle is repeated.

If the last two paragraphs are wild in imagining all the work to come from the oxygen, let them be modified so as to read part from the oxygen and part from the carbon. The writer does not believe, nor disbelieve, them. He simply feels that without evidence they come as near being good poetry as the rhetorical specimens above quoted, which, without evidence, have been thrown at him as facts.

Mr. G. K. Chesterton, who, whether or not thought of as "glib", is not likely to be accused of assumptions,

either false or true, of the particular knowledge now commonly classified as "science", has stated the case in graphic form ("The Uses of Diversity," 1920), the asterisks, in the quotation, standing for further embellishments:

"There is a certain kind of modern book which * * * ought to be blown to pieces with the dynamite of some great satirist like Swift or Dickens * * *. The kind of book I mean is the pseudo-scientific book. And by this I do not mean that the man who writes it is a conscious quack or that he knows nothing; I mean that he proves nothing; he simply gives you all his cocksure * * * opinions and calls it science. Books are coming out with so-called scientific conclusions—books in which there is actually no scientific argument at all. * * * I should like some evidence."