ON SOME NEEDED CHANGES AND ADDITIONS TO PHYSICAL NOMENCLATURE.

By Professor A. E. Dolbear.

I.—Physics is now defined to be the science of energy. Previous to 1840 what was known concerning energy was embodied in Newton's Laws of Motion, and was confined to what we may call molar mechanics, to distinguish it from atomic and molecular mechanics, which has since that time been developed. Friction was looked upon as resulting in an absolute loss of energy, and no attempt appears to have been made to find it in other forms. Both Rumford and Davy proved, to their own satisfaction, that friction resulted in the *creation* of heat—an idea entirely different from the conception of heat then in vogue, that it consisted in imponderable corpuscles. No attempt was made to find the quantitative relation between molar energy expended and the heat produced, so that many years elapsed before any advance was made beyond the qualitative work of Rumford and Davy. Even for a time after Faraday's researches had established a quantitative relation between chemical reactions and electricity, the facts were looked upon as rather curious information, out of relation with physics proper, and so the latter was kept strictly what is involved in

$$\text{Energy } E = \frac{m v^2}{2},$$

the *form* of the energy being modified by so-called "Mechanical Powers," the lever, the pulley, the inclined plane, etc. Since 1840, however, through the labors of Mayer, Joule, Thomson and others, the quantitative relations between the various known forms of energy have been determined with great precision, and has led to a complete and inclusive generalization of the laws of energy—namely, that the energy in the universe is a constant quantity, the form that it may assume at a given time and place depending solely upon the other forms of energy which are present at the same place at that time. By the *form of energy* is meant *the character of the motion that embodies the energy*, for when there is no motion there is no energy, so that each different form of motion is a different form of energy. Rectilinear motion is a different form from rotatory motion, inasmuch as in rectilinear motion there is a change of position in space of the centre of mass, while rotatory motion does not involve such change, yet both embody energy though each in a special form and each should have a specific name.

Generically, all motion of translation in space is called mechanical motion or molar motion, and its energy, once called its *vis viva*, is proportional to $\frac{m v^2}{2}$, and is true for masses of all dimensions. Nevertheless, what a given amount of energy will do depends solely upon its form. Rectilinear motion cannot continuously produce rotatory motion; but vibratory motion can. For convenience in descriptive work as well as for clearness of conception—the latter of great importance—it is necessary to have specific names for the various forms of energy. As each form embodies a particular form of motion, one will only need to specify the various possible forms of motion in order to cover all possible cases. We have then the following table for such mechanical or molar motions:

$$E = \frac{m v^2}{2} \left\{ \begin{array}{l} \text{Rectilinear, like a locomotive upon a straight track.} \\ \text{Rotatory, like that of a balance wheel.} \\ \text{Vibratory, like that of a tuning fork.} \\ \text{Curvilinear, like that of a projected cannon ball.} \\ \text{Spiral (unusual), like some forms of projected rockets.} \\ \text{Vortical, like smoke rings.} \end{array} \right.$$

As the energy of each of these forms is expressed by the same formula there is no way of identifying either of them, except by some roundabout expression as "The energy of vibration," "The energy of curvilinear motion." It is true that for one of these forms we have a particular name, *sound*, for vibratory motion, provided its frequency is within the limits of hearing, but as the same name is applied to the sensation itself we are without a distinctive name.

II. If instead of large masses we consider atoms and molecules, it will be clear at once that the same *forms* of motions are possible as with the large masses, and the same general descriptive terms are applicable. Thus for an atom there is a rectilinear motion which we call its free path, but for its vibratory motion we use a distinct and and specific name, *heat*. Also for the rotation of the atom in its own plane, we have the specific name, *electricity;* for possible curvilinear spiral or vortical motions there are no names.

The energy embodied in atomic and molecular motions exclusive of rectilinear, that is, that do not involve a change of position of the centre of mass or of inertia of such atom is generally called *internal energy*, and if we let ϵ represent its value then the complete expression for the energy of the atom will be

$$E' = \epsilon \frac{m v^2}{2}.$$

Now such changes and conditions as are involved in what we call *latent heat*, *specific heat* and *specific inductive capacity* are all involved in that factor ϵ, but the terms specific heat and latent heat are certainly misapplied, for whatever the forms of energy may be, they are certainly not heat, consequently not vibratory. Specific names then are needed for these.

III. The observed transferrence of energy from one atom to another without contact has necessitated the theory of the ether, and we know the rate of transmission of some forms of energy in this medium to be 186,000 miles per second. It follows then that energy resides in this medium in some form, and it is a matter of experiment to determine the particular form. Thus what is called light and sometimes heat is known to have an undulatory form, and the mechanism of the conditions may be easily perceived. Thus, let the dark

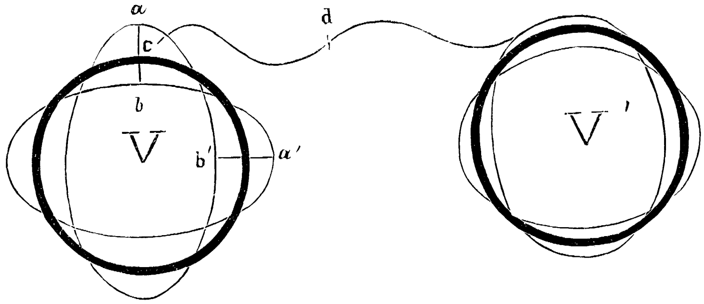

FIG. 1.

ring V (Fig. 1), represent an atom of any matter, say hydrogen (the simplest form of vortex ring). Suppose it to vibrate its fundamental, then will the point c move over the line $a\ b$, and the circle will assume an elliptical form alternating with another ellipse with major axis at right angles to the former, in the line

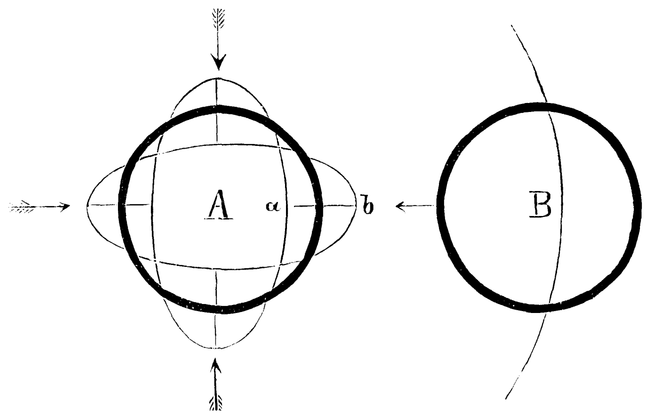

FIG. 2.

$a' b'$. The line $a\ b$ represents the displacement of the point c, in other words, it is the amplitude of vibration of the ring. It is such vibratory motions of atoms that constitutes what we call heat, and we know furthermore that such vibratory motion sets up in the ether surrounding the atom-undulations which constitute what are called rays. Such undulations $c\ d$ travel outwards in every direction, and the length $c\ d$ is called a *wave length* $\lambda = \frac{V}{n}$, v being distance traversed during n vibrations, v being quite independent of the amplitude $a\ b$. As such displacement $a\ b$, whether it be small or large, sets up corresponding motions in the ether, it follows that any displacement of matter in ether, whether it be a part of an atom or the whole atom, that is, whether it be so called internal energy or external energy, will originate in the adjacent ether a corresponding movement, which will travel outwards with a velocity which will depend solely upon the translatory property of the ether. This property is sometimes called *elasticity*, but as elasticity is a property of matter and ether is not matter, and as the actual velocity of transmission is so many times greater than in any elastic matter we know, I prefer to say I don't know anything of the specific properties of ether, and do not say that it is even elastic. The undulatory motion in ether is utterly unlike the vibratory motion of the matter that originates it and it ought not to be called by the same name. Furthermore, as atoms differ in mass, so will their rates of vibration differ when they possess the same absolute amount of energy. Velocity in this case will be equal to amplitude $a\ b$, the space point c passes over during one vibration. If m and m' be two atoms of different masses having equal energy of vibration, then,

$$E = \frac{m\ v^2}{2} = \frac{m^1\ v'^2}{2} \text{ and } \frac{m}{m'} = \frac{v'^2}{v},$$

that is, the square of their velocities is inversely as their masses, so that wave length in the ether will vary as the mass of the atom. As such rays in ether vary only in amplitude and wave length, not in form nor in the medium, it is time to stop speaking of some of them as heat rays, some of them as light rays, and still others as actinic rays. These names characterize *effects*, not the rays themselves; what any one will do depends solely upon what kind of matter it falls upon. What we call light itself is purely a physiological phenomenon and does not exist independent of eyes, and it is hence improper to speak of the velocity of light, however convenient the expression may be. It is what produces light or heat or photographic effects that has velocity and this has the more appropriate name of *radiant energy*.

For a similar reason it is manifestly improper to speak of the temperature of space. Absolute space can have no temperature, for temperature is a function of matter. The temperature that a mass of matter would have in space must depend first upon its own constitution, and second, upon the number and wave lengths of the rays of radiant energy that fall upon it, and these would not necessarily be alike in any two points in space. Let V and V′ be two atoms at any distance apart, then if any ray from V falls upon V′, the latter will be made to vibrate provided its possible rate of vibration coincides with V, in which case it is a simple example of sympathetic vibration, the amplitude only being less than that of V. If its possible rate is not the same then it will not be vibrated by the ray; in other words it will not be heated by it and consequently it will have no temperature.

IV. Again, consider other physical conditions in and about a vibrating body. Bring any light body that is free to move in proximity to a vibrating tuning fork and such body will be apparently attracted by the prong and will stick to it while the vibrations continue. The average density of the air near the fork is less when it vibrates than when it is still, and consequently any object near it will be more pressed by the air on the opposite side than on the side adjacent to the prong. Precisely similar conditions are present with a vibrating atom. Let A (Fig. 2), be such an atom as before vibrating in its slowest period, $a\ b$ will be the amplitude of vibration, then will there be a less density in the ether at each of the four extremes of the major and minor axes of the ellipses, and consequently a pressure at the four points in the direction of the arrows. The space within which the density is appreciably less may be called the *field* of the atom and if another atom B be wholly or in part within that field it will be subject to pressure towards A. If atom B vibrates synchronously with A there will be no more than a brief temporary disturbance when the two will adhere together by pressure from without and will then constitute what is called a molecule. If, however, the vibratory period of B is not commensurate with A's then after impact the two must separate, either to renew contact and recession or to bound away quite out of each other's field. The same may happen to two similar atoms when the amptitude of vibration becomes very great, they may bound quite out of each other's field, only renewing contact but not cohesion. This is called *dissociation*. This tendency to unite exhibited by atoms and explained as due to purely mechanical conditions was formerly called chemical affinity, but is now called *chemism*. The selective agency observed being due to relative rates of vibration, the possibility of uniting and the strength of the compact depending upon the harmonic relations involved. The motion set up in the ether at the parts of maximum displacement which results in chemism is different from the undulatory and may be distinguished from it as *pulsatory*.

If an atom spins upon an axis at right angles to its plane then any point c, (Fig. 1) in the circumference will be displaced the diameter of the atom every half rotation, and this displacement must set up in the ether a disturbance as great as though the amplitude of vibration had been as great as the diameter of the atom, but the motion of the point c being continuous and uniform instead of vibratory, the motion in the ether must be helical, the diameter of the helix at the atom being just equal to the diameter of the atom, but expanding outwards as a cone and is sometimes treated as a line or tube of force in treatises on electricity and magnetism. This motion in the tube will be right handed or left handed, depending upon which side of the atom the motion is traced from.

Now all the phenomena of magnetism tend to show that wherever it is present there matter is rotating in a plane at right angles to the direction of the magnetic axis, the magnetism being a form of energy in ether, being related to rotating atoms as undulations in ether are to vibrating atoms.

Lastly, there are many good reasons for the belief that matter itself consists of vortex rings of ether in the ether, and that they also embody a certain form of energy, which simply on account of its form is persistent, that is, unlike other forms of energy it is not exchangeable with them. In this view inertia is a law of energy and not a property of matter.

The following table gives a synoptical view of the various forms of energy and the names they have. Where there are no names an interrogation point is placed to indicate the lack. To the writer it appears as if each specific form of energy should have a specific name, but he is aware of the difficulty of finding suitable names and getting them adopted. If this want is felt by others then a committee of suitable persons might be appointed by the American Association for the Advancement of Science, who might consider and recommend appropriate names as did the British Association for Electrical Science some years ago.

TABLE OF FORMS OF ENERGY.

1. *Mechanical or Molar Motion.*

	Form.	*Name.*
$E = \frac{mv^2}{2}$	Rectilinear	?
	Rotary	?
	Vibratory	Sound.
	Curvilinear	?
	Spiral	?
	Vortical	?

2. *Atomic and Molecular.*

	Form.	*Name.*
$E' = \varepsilon \frac{mv^2}{2}$	Rectilinear	Free path.
	Rotatory	Electricity.
	Vibratory	Heat.
	Curvilinear	?
	Spiral	?
	Vortical	?

3. *Atomic and Molecular.*

	Form.	*Name.*
$E' - E = \varepsilon$	?	Specific heat.
	?	Latent heat.
	?	Specific Induc. Capac.

4. *In Ether.*

	Form.		*Name.*
$E = ?$	Rectilinear		?
	Vibratory	Pulsatory	Chemism.
		Undulatory	Radient Energy.
			Pseudo Light. Heat. Actinism.
	Rotatory, Curvilinear,	Circularly and Elliptically	Polarized Light.
	Spiral		Magnetism.
	Vortical		Matter.

THE SPANISH MACKEREL AND ITS ARTIFICIAL PROPAGATION.

By Chas. W. Smiley.

This fish, *Cybium Maculatum*, is in general appearance very like the common mackerel. It is larger, however, averaging seventeen to twenty inches in length. When first described it did not exist in our waters, but was abundant in the Gulf of Mexico and the Caribbean Sea. Its first appearance was about 1850. It then began to be taken as a food fish. It began to be caught in the Chesapeake about 1870. About 1872 or 1873 it appeared in Narragansett Bay, when three or four hundred were taken at one haul of the seine, but the fish did not subsequently reappear.

The Chesapeake Bay has been annually visited by large schools for several years, where it is known as the "Bay mackerel." None were known to have been marketed there prior to 1870, but in 1879 1,300,000 of this fish were sold, and the season of 1880 is expected to yield 2,000,000. They were taken in pound nets and gill-nets. At Cherrystone, Md., there are fourteen pounds, which average a catch of 500 to a day. As many as 4,000 per day have been taken in a single pound on the eastern shore of the Chesapeake, while 2,500 is not a rare catch with one pound. The Bay fish are, however, smaller and leaner than those caught further north.

As this fish refuses the hook its capture is limited to pounds and nets. The first pound in the Bay was built in 1875. Now there are 164. The first gill-net used there was in 1877, while now there are 175 men fishing by this means. A net 100 fathoms long will average forty fish per twenty-four hours, the fish weighing from one and a half to two pounds each.

In the New York market the price per pound ranged from eighteen to thirty cents during 1879; for May, 1880, from fifteen to forty cents; but owing to the large shipments in June the price fell to ten to fifteen cents. On special occasions the fish have been sold readily at one dollar per pound. The catch of 1873 at Newport, R. I., was sold at prices varying from seventy-five cents to one dollar per pound.

This fish usually appears in the Chesapeake in May, when the temperature has reached 65° or 70°, and the number increases until the middle of June. They remain abundant until September, and diminish as the temperature of the water falls, until, in early October, nearly all have disappeared. They come in small schools, but later get scattered, and often quite isolated. Before leaving, the schools seem to be somewhat reformed.

The United States Fish Commission, under the management of Professor S. F. Baird, the Secretary of the Smithsonian Institution, has long desired to experiment upon the artificial propagation of this fish, but has been deterred by the lack of knowledge of its spawning time and places. These were both discovered June 1st by Messrs. Earll and McDonald, Assistants of the Commissioner. At that date the lower Chesapeake, especially Mobjack Bay, was found to contain large numbers of spawning mackerel. This opened the way for experiments, and Professor Baird was ready to seize upon the opportunity. He directed Mr. Earll to make every effort to hatch some fish.

June 21 Mr. Earll started for Crisfield, Md., on the eastern shore of the Chesapeake, and during the following ten days there conducted his experiments.

He found the number of eggs produced by a single fish to be from 50,000 to 500,000, according to the size of the fish, the latter number having been taken from a fish weighing one and three-fourths pounds. Instead of all the eggs ripening at once, as is true in the case of the shad, only a part are thrown at a time, and at intervals of a few days, probably extending through two or three months. This is analogous to the cod, which deposits its eggs at intervals during five or six months. Different individuals of mackerel were found to vary in their time of spawning; some ripening a considerable time before others, and the males seeming to ripen somewhat in advance of the females. From 40,000 to 130,000 eggs were obtained at one time from a single fish. The shad, however, yields only 20,000 to 30,000 as its fruits of an entire season. The cod, on the other hand, are so prolific that a twenty-one pound fish has yielded 2,700,000 eggs, and a seventy-pound fish has yielded 9,000,000 eggs.

When the fish had remained in the nets several days Mr. Earll found that the most of the spawning females had deposited all their ripe eggs. The greatest quantities were secured from individuals that had remained in the pound but a few hours. It is believed that when confined the female presses against the netting in its efforts to escape and produces an abnormal discharge of eggs; but it would result in the impregnation of a much larger number of eggs than would chance to be fertilized in a natural way. The males and females being caught side by side in considerable numbers, both eggs and milt would be present in the water in such quantities that