

It has been shown that the main crops of the South are cotton and tobacco. There was a time when the Southern States cared to produce nothing else, and with the foreign gold those crops brought they could buy the necessities of life. That day has passed, and the farmers and planters of the Southern States see the advantage of not depending on a single crop. The following table has been prepared from the best official sources:*

States.	Corn.	Wheat.	Oats.	Hay.	Potatoes.
Eastern States.....	\$47,210,900	\$15,213,875	\$27,021,000	\$144,825,000	\$27,036,500
Western States.....	\$25,128,300	\$98,992,874	\$8,536,900	\$9,011,570	\$1,603,960
Southern States.....	\$37,390,500	\$3,627,500	\$19,288,900	\$3,844,380	\$1,189,300

The great difference in the value of the products near to and far from the seaboard makes the above comparison rather unfavorable for the West. Below I have prepared a table showing the average yield of corn, wheat, and oats, and also the value per acre in the Eastern, Western, and Southern States:†

States.	AVERAGE YIELD PER ACRE.			AVERAGE VALUE PER ACRE.		
	Corn.	Wheat.	Oats.	Corn.	Wheat.	Oats.
Eastern States.....	35	17	34.8	\$24.65	\$24.27	\$15.05
Western States.....	31.4	15.4	33.3	9.05	15.09	7.92
Southern States.....	18.4	9.7	19.1	9.19	11.60	9.38

The highest average yield of wheat is in the Eastern States, where wheat averages 17 bushels to the acre; in the Western States, 15.4; and in the Southern States, only 9.7 bushels. The average value in the Western States of the wheat crop is \$9 per acre less than in the Eastern States; corn, \$15 an acre less; and oats \$7 less. Lastly, in this connection is given a table showing the value of the oxen, cattle, sheep, and hogs annually produced in the three great geographical divisions of the United States:

States.	Oxen and other Cattle.	Sheep.	Hogs.
Eastern States...	\$61,006,452	\$14,587,249	\$20,552,899
Western States...	121,503,102	17,912,600	68,262,653
Southern States...	90,116,341	17,706,577	52,530,936

The Hon. David A. Wells, in his valuable essay on the "Elements of National Wealth," says:
"Be the value of the annual product"

* Report of the Commissioner of Agriculture for 1878.

† This statement is based on the Reports of 1877.

the largest proportion of such product must necessarily be consumed as rapidly as produced, in order that the individual constituents of the nation—its men, women, and children—may simply live and make good the loss and waste of capital previously accumulated, leaving but a small fraction of the annual product in the form of surplus, or accumulation, which can be used for effecting future increased production and development."

The progress of a nation does not depend on what it has accumulated, but on the continuity of those processes and resources by which the wealth was won in the first place. In this, as our tables abundantly prove, the nine Western States stand pre-eminently ahead. The greatest wealth, the highest prosperity, is achieved where the two great occupations are the most equally divided. We have seen the dangers of an excessive development of manufacturing interests in England, and a neglect of agriculture; we have seen the evil effects of the other extreme in the Southern States. Each of the great geographical sections of our country may profit by the few facts herewith presented. The Eastern States have already awakened to the necessity of more scientific farming. The rapid increase in number of those engaged in manufacturing occupations in the nine Western States shows that every year the two great industries are becoming more evenly distributed in the West. In its eagerness to compete with the Eastern States the West should not forget that the foundation of its strength lies in its food-producing powers. Cheap food as well as cheap products of the mill and shop should be the aim. These comparative statements aid greatly in studying the nation as a whole. It is only by such a study that we may hope to find out its strength and weakness, its success and failure. It is from such a view of our wants that all of us gain common sense, common aims, and a deeper faith in the future of the Republic.

ROBERT P. PORTER.

AN ATTEMPT AT A SYSTEMATIC CLASSIFICATION OF THE VARIOUS FORMS OF ENERGY.*

By Dr. O. J. LODGE.

1. EVERY action which takes place between two bodies is of the nature of a *stress*. A stress consists of two equal opposite forces (called action and reaction, or force and anti-force), one of them exerted by the one body, and the other by the other; and it is impossible for one force to be exerted without the other.

2. Whenever a body exerting a force moves in the sense of the force it exerts, it is said to do *work*;† and whenever a body exerting a force moves in the sense opposite to that of the force it exerts, it is said to have work done upon it, or to do anti-work, the quantity of the work being measured in each case by the product of the force into the distance moved through in its own direction.

3. Whenever two bodies exert a stress on each other, they are in contact; and if they move, they move together the same distance; hence, since the force equals the anti-force, the work done by the one in any movement is equal to the anti-work done by the other.

4. The working power|| of a body is measured by the average force it can exert, multiplied by the *range* or distance through which it can exert it. The working power of a body may be increased or diminished by increasing or diminishing either the force or its range, or both; and it must remain dormant so long as external circumstances do not allow it to exert a force through a distance.

5. Whenever work is done upon a body, an effect is produced in it, which is found to increase the working power of that body (by an amount not greater than the work done); hence this effect is called *energy*, and it is measured by the quantity of work done in producing it.¶ Whenever work is done by a body, i.e., anti-work done on it, its working power is found to be diminished (to at least the extent of the work done), and it is said to have lost energy—the energy lost being measured, as before, by the anti-work done in destroying it.

6. But in every action taking place between two bodies the work is equal to the anti-work (§ 3); hence the energy gained by the first body is equal to the energy lost by the second; or, on the whole, energy is neither produced nor destroyed, but is simply transferred from the second body to the first. (Remember foot note to § 1.)

To summarize then: Work creates energy; anti-work destroys it; so both together simply transfer it. Or, in other words, the transference of energy requires a stress to act through a distance, and involves therefore two equal opposite works. If it were possible to obtain a force without its anti-force, or if it were possible for two bodies exerting stress on one another to move over unequal distances (§ 3), when it would be possible to obtain work without the anti-work, and thus to get a source of new energy (technically called the perpetual motion); but, as a fact of experience, it is not possible.

7. When work is done upon a body, different kinds of effects can be produced, depending both on the nature of the body and on the way in which the forces doing the work are applied to it; and these constitute the different *forms* of energy.

* From the *Philosophical Magazine*.

† The term *body* is here used in its most general sense, viz., as standing for a piece of matter in general, without regard to size. It may mean a planet or an atom, and it may even apply to such extra-material things as the ether and the hypothetical ultra-mundane corpuscles, or to anything else which is sufficiently like ordinary matter to be capable of possessing energy and of doing work therewith.

‡ It seems preferable to speak of the work as being done by the *body* rather than by *force*; though the latter expression is undoubtedly convenient sometimes.

§ This step is rendered necessary by the preceding one of considering the work as done by the *body*. If it is the force which does the work, it is unnecessary.

|| Or power of doing work. But either term is objectionable, because *power* means *rate of doing work*. The term *entropy* has been used, but I believe that the accepted connotation of this word is now different.

¶ This definition of energy, as the effect produced in a body by an act of work, is not so simple as the usual one—"the power of doing work;" but this latter definition seems a little unhappy. For energy is power of doing work in precisely the same sense as capital is the power of buying goods. Now a sovereign has an infinite power of buying goods if it has any at all—twenty shillings worth being bought whenever it is transferred from one man to another. The proper statement is that a sovereign usually *owns* upon the man that possesses it a certain buying power, which power he loses when he has transferred it, and in this sense money is a power of buying goods. It does not, however, necessarily confer upon its owner any buying power, because there may not be any accessible person to buy from; and if there be he may have nothing to sell. Just so with energy; it usually, though not necessarily (see § 14), confers upon the body possessing it a certain power of doing work, which power it loses when it has transferred it. The analogy here indicated will be found useful in teaching.

Energy corresponds to capital.

Doing work corresponds to buying.

Doing anti-work corresponds to selling.

The transfer of capital is accompanied by two equal opposite acts, buying and selling; and it is impossible for one to go on without the other. Hence the algebraic sum of all the buying in the world is always zero; this is the law of the conservation of capital.

8. We can proceed to classify the forms of energy by first of all considering how the effects produced depend upon the forces applied to the body.

If these forces have no resultant (i.e., if they are in equilibrium), the body will be *strained*, and will exert a corresponding stress.

If the forces have a resultant, the body will be *moved*;* and the motion will be either a translation or a rotation, or both, according as the forces can be reduced to a single finite resultant, a resultant zero at infinity, or to both combined.

Similarly, the strain may be analyzed into compression, elongation, and shear, or a combination of them, according to the way the forces act; but this division does not appear to be of much use for our present purpose.

All these effects are forms of energy, because the working power of the body in which they are produced is in general increased; i.e., the body is rendered capable of doing work as soon as the proper condition is supplied. (See § 4.)

Thus a steadily strained elastic body is exerting force or pressure; but its point of application is stationary; allow it to move, and work is immediately done. A body in free motion is passing through space, but it is not exerting any force; supply a resistance, and work is immediately done.

9. Energy, therefore, has two principal forms:

(1) The free motion of bodies relatively to one another.

(2) The separation of bodies from one another against stress.

And to these may be added for convenience the rapid alternation from one form to the other, called vibration.

10. The two fundamental forms of energy correspond to the two factors in the produce work.† A body exerting force possesses energy, and a body moving through space possesses energy; but a body is not doing work unless it is both exerting force and moving through space.

The energy possessed by matter in motion is called *kinetic*. The energy possessed by matter exerting force is called *potential*. It might with great propriety be called *dynamic* energy; and it has been very conveniently called *static* energy,‡ in opposition to kinetic. Of the two factors, F and s, the s, the distance, corresponds to s; there is motion through space, but no force. potential

11. Whenever work is being done both factors must be present—that is, both kinetic and potential energy; and the energy is always passing from one of these forms into the other while the work is being done. For if the motion of a body is *with* the force which acts upon it, its speed must increase; and if the motion is *against* the force, the speed must decrease; while in the first case the available distance through which the force can act, or the *range* of the force, is decreasing, in the second increasing.

12. The groups into which the forms of energy have been arranged (§ 8)—viz., strain, rotation, translation, and vibration—may now be subdivided further, by considering how the effects produced when work is done upon a body depend upon its nature and size.

A convenient division of bodies, according to size, will be:

1st. Masses comparable in size with the human body, which may be called ordinary masses.

2d. Masses incomparably larger, as planets.

3d. Masses incomparably smaller, as particles or molecules.

4th. The ultimate atoms.

All these material bodies agree in general properties, and differ only in size. But distinct apparently from these there exists an unknown *something*, which is material enough to be capable of possessing energy, to disturbances in which electrical phenomena seem to be due, and of which probably an aspect has been called ether. This must therefore constitute a 5th group, differing from the others apparently in respect of nature, not of size.

13. All these groups of bodies may be strained or set in motion in various ways when work is done upon them; and the groups into which the known forms of energy are thus thrown are exhibited provisionally in the table on next page.

It is quite possible that the form of energy indicated in compartment No. 4 would be better placed in No. 8, those now in No. 8 being placed in No. 12; but I have placed them as they now stand because they are closely connected with the vibration forms in the same rows. Moreover the true position of gravitation energy cannot be properly defined till we know more about it. It may have to come under the kinetic head—the motion of Le Sage's corpuscles.

Probably the arrangement of the forms in the last row may be improved, but I am not sufficiently acquainted with the Maxwellian theory to do it. Neither do I know whether one is justified in pointing out an analogy between the two forms of strain indicated in No. 20 and simple and torsional shear—or whether one may imagine that the volume elasticity and Young's modulus of the "something" are infinite, but that its rigidity is finite though high. An apparently consistent, though rather hazy mental image of some obscure phenomena, may be built up on a basis like this; but it is too speculative to be mentioned further here.

14. The power of doing work conferred upon a body by the possession of energy does not depend upon the absolute quantity of that energy only, but on its transferability. If it is not transferable, the body possessing it has no power of doing work.

15. Energy which can be guided, and all, or nearly all, transferred to any body at pleasure, is called a high or available form of energy, and is said to be capable of doing "useful" work, this work being done every time it is transferred in desired directions.

Energy which is nearly incapable of being guided, and which transfers itself in directions not required, is called a

* And possibly strained as well. It is only forces which, like gravity, act uniformly on every particle of a body, that can move an ordinary elastic solid without straining it.

† Energy and work are not to be confounded together; and all such phrases as "accumulated work," "conservation of work," "conversion of heat into work," "work consumed," etc., should be eschewed. Energy is not work, but work can be got out of it if the proper condition be supplied. It is, in fact, *possible* work.

‡ The expression *possible energy*, however, is meaningless; so also is the expression *actual energy*. All energy is *actual* and *real*—potential just as much as kinetic; and all represents *possible work*—that is, work that will become actual as soon as the other factor is supplied.

§ The cause of the stress exerted by a strained body in any particular case is not in general known, and it may easily turn out often to be ultimately due to a kinetic phenomenon, as it certainly is in the case far of the stress exerted by a compressed gas; nevertheless it may still be called static energy so long as the cause of the stress is not under consideration.

low or unavailable form of energy; and the work done at each of its undesired transfers is called "useless" work.*

16. The distinction between high and low forms of energy is a relative one, and depends on our present power of dealing with matter.

Masses of matter comparable to our own bodies in size can be handled and dealt with singly; and so they can in general be caused to do work upon, and therefore transfer their energy at pleasure to, any of the numerous accessible bodies which are competent to receive it. Hence energy possessed by them is generally of a high form.

17. Planetary masses can be dealt with singly indeed, but so singly that there is scarcely any other body accessible to which their motion can be transferred.† (See §§ 4 and 14.)

18. The energy of moving molecules is not very available to us, because we can only deal with them statistically and not individually. There is a large amount of relative motion and transference of energy constantly going on among individual molecules; but, as we have no control over it, the work done is useless, and the energy unavailable. The only part of the energy which can be transferred at will to external bodies is that due to the average state of the moving molecules; and it is not possible to transfer even this unless some other mass is accessible, the average state of whose molecules in respect of motion or strain is in some way different, so that the one is able to do work upon the other.‡

BODIES.	ENERGY OF MOTION, OR KINETIC ENERGY.		ENERGY ALTERNATELY KINETIC AND POTENTIAL.	ENERGY OF STRESS, OR POTENTIAL ENERGY.
	Rotation.	Translation.	Vibration.	Strain, etc.
Planetary masses.	1. <i>E.g.</i> Earth's diurnal motion.	2. <i>E.g.</i> Earth's annual motion.	3. <i>E.g.</i> The moon's libration. Tides. Pendulums.	4. Energy of gravitation. <i>E.g.</i> A head of water. A raised weight.
Ordinary masses.	5. <i>E.g.</i> Fly-wheel.	6. <i>E.g.</i> Cannon-ball. Rivers.	7. Sound-vibrations. <i>E.g.</i> Tuning-fork.	8. Energy of strained elastic bodies. <i>E.g.</i> Watch-springs.
Particles or molecules.	9. Part of the heat-energy of fluids.	10. Most of the heat-energy of gases.	11. Heat-energy of solids.	12. Energy of molecular stresses. <i>E.g.</i> "Internal work."
Atoms.	13. Unknown motions which take place during the act of chemical combination and during dissociation.		14. The translation of atoms is observed in electrolysis.	15. The period of atomic vibration is observed by the spectroscope.
Something.	17. Magnetism.	18. Electric currents.	19. (1) Discharge of accumulators. (2) Radiation.	20. (1) Electrostatic stress. (2) Electromagnetic stress.

[The numbers in the compartments are merely for convenience of reference.]

Now, since all accessible bodies have very large stores of molecular energy, it follows that a very great portion of the energy which belongs to the molecules of a body must be totally unavailable to us, because it can never be got rid of or transferred. And even the portion which can be transferred at pleasure to some larger body, if not made use of quickly, will be found to transfer itself to neighboring molecules and in directions not required, and will waste itself in doing useless work. Hence molecular energy is called a low form.

19. Atomic or chemical energy seems at present to rank a little higher than molecular energy, for though one way of availing ourselves of it is by converting it into molecular energy (heat), and then doing useful work with the balance of the average effect by which the body heated excels its neighbors, yet animals and galvanic batteries are able to do useful work with it in a more direct and less wasteful fashion.

The unknown or electrical energy appears to rank distinctly above the energy of molecules, because we have found some remarkable and indirect means of transferring the energy of electric currents to ordinary masses by the intervention of electro-magnetism with a comparatively small waste.

20. When energy passes from a higher to a lower form it is said to be degraded, and when it has no availability at all it is called dissipated.¶

Energy is degraded when it is transferred from masses of ordinary size to the molecules of which they or others consist (§ 18).

The two fundamental forms of energy are those due to motion and those due to strain (§ 9). Now, whenever motion takes place against friction, some energy is always transferred to the molecules of the rubbing surfaces; and

* The distinction between useful and useless work is quite accidental, and belongs more to economics than to physics. An engineer will often degrade the whole of a large quantity of energy in order to produce some superficial result which he happens to desire at the moment, *e.g.*, when a planing machine smooths a surface; or when a locomotive transfers passengers or goods between places on the same level.

† The well-known exception is the ocean, which by the agency of the moon is put into a slightly different state of motion from the rest of the earth; and a minute portion of the earth's energy of rotation is constantly being transferred to it. A portion of this tidal energy is now available to us, and may be made to do useful work.

‡ Hence the kinetic energy of the earth is of no more use to us than a bank-note to Robinson Crusoe.

§ An analogy may be drawn between the molecular energy of a body and the money of a bank, of which a reserve fund is kept for internal transfer and transactions between customers, while the excess gets invested in external concerns which have a deficiency, and so becomes available for doing useful work. To make the analogy more complete, the clerks should be uniformly dishonest, or the coffers insecure, so that stored money should dribble away.

¶ It is then of no more use to us than is our money to the inhabitants of Mars, who have no means of getting at it. Its terrestrial transferences are to them useless.

whenever strain is produced in imperfectly elastic bodies, some energy always passes to the molecules.

But in practice no motion takes place without friction; and all bodies are imperfectly elastic. Hence energy is continually getting dissipated; or, in other words, at every transfer of energy between ordinary bodies under ordinary circumstances, some of it is always and necessarily degraded into a lower and less available form.*

It may be useful to append the following summary of the contents of the sections: 1. Newton's third law. 2. Definition of work, + and -. 3. Denial of "action at a distance." 4. Definition of working power. 5. Definition of energy. 6. Conservation of energy, and first law of thermodynamics. 7. Possibility of various forms of energy. 8. Classification of the forms of energy. 9. The fundamental forms of energy. 10. Kinetic and potential energy are related to the two factors in the product work. 11. Transformation from one form to the other. 12. Further subdivision of the forms of energy. 13. Classification table.

14. Distinction between energy and what was once called entropy. 15. Distinction between available and unavailable energy, and between useful and useless work. 16. Reason

1 shows one of the arrangements adopted by the inventor, and represents the lower portion of the plunging rod of a thermometer designed for ascertaining the temperature of liquids. The motion of the final and middle tube is sufficient, if further increased by a toothed wheel, to move the needle of a graduated scale. This part of the system is not represented in Fig. 1. Fig. 2 gives the general arrangement of a new style of thermometer constructed by M. Coret. The mechanism and the tubes which form the thermometric apparatus are fixed to the same plate, and set in a wooden lyre-shaped frame. The thermic apparatus is fitted to the plate at the point, A; the extremity, B, is connected with a lever which actuates the toothed sector that serves to move the index needle.

The cheapness with which the apparatus can be constructed and their very great sensitiveness are the two advantages claimed for this system.

BREAKING HORSES BY ELECTRICITY.

DIFFERENT methods have often been proposed for stopping and controlling mettlesome or restive horses, but there is none more ingenious and more efficacious than the one



A GALLOPING HORSE SUDDENLY BROUGHT TO A STAND-STILL BY THE ACTION OF THE ELECTRIC BIT.

why the energy of ordinary masses is available. 17. Reason why planetary energy is almost unavailable. 18. Reasons why molecular energy is much of it unavailable, and second law of thermodynamics. 19. Extent of availability of atomic and of electrical energy. 20. Dissipation of energy.

CORET'S METALLIC THERMOMETERS.

M. CORET's metallic thermometers consist of an arrangement of tubes of different metals (zinc and iron or copper and steel, for example) placed parallel to each other and soldered together at their ends so as to form a series in which

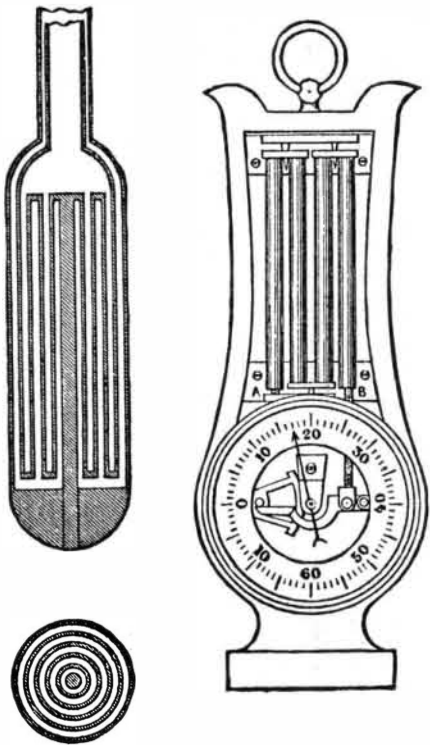


FIG. 1.

FIG. 2.

CORET'S METALLIC THERMOMETERS.

the differences of expansion between two consecutive tubes are added as many times as there are pairs employed. Fig.

* For instance, during every quarter-swing of a free pendulum, energy is being transformed from kinetic to potential, or *vice versa*; and is being transferred from the unknown gravitation agent to the mass of the pendulum, or back again. Some, however, is dissipated every time, and ultimately the pendulum must stop.

invented by M. Defoy, and the advantages of which have recently been brought to the notice of the Societe d'Encouragement by M. Bella, the Superintendent of the Omnibus Company of Paris. The system consists simply in the use of small Clark apparatus contained in a box, which can be easily placed under control of the coachman or rider. In the interior of the reins is a metallic conducting wire, terminating at one end in the bit, and at the other in the magneto-electric apparatus. By turning the crank of the electromagnet a current is induced which, acting on the mouth of the horse, so surprises him that he stops and remains passive. By joining a few kind words to the action of the electricity, the most dangerous horse is quickly mastered. M. Bella reports that M. Defoy has experimented with the apparatus in his presence, at the depot of the Omnibus Company, where are collected together some of the most vicious and dangerous of horses. A Hungarian horse, which was very difficult to shoe, was led to the smithy and there became very vicious, whereupon the electric reins were applied. After a few moments of experimenting he allowed himself to be patted on the back and shoulders, then he permitted his legs to be touched, and finally his hind feet to be raised—the latter being something that had always been difficult to accomplish.

The smith struck one of his hoofs without causing him to rebel, and then his shoes were changed without the necessity of fettering him, and without his resuming his dangerous efforts at resistance. The Superintendent of the Parisian Cab Company has also recently borne witness to the efficacy of this process. "The experiment," says M. Camille in his report, "was made on several horses which, until then, it had been impossible to shoe; but all without exception submitted to the operation under the influence of the electrical apparatus. One horse that was to be shod went so far as to lie down and roll over and over on the ground, all the while struggling, defending himself, and fighting against everything; nothing could subdue him. I then had recourse to M. Defoy's apparatus, and, on the first trial, much to my surprise, the feet of the intractable horse were lifted without any great difficulty, and on the second trial it was as easy to shoe him as if he had never made the least resistance; the animal was conquered."

M. Defoy has recently brought before us, says the editor of *La Nature*, a dangerous horse which, after putting him to the gallop, he brought to a sudden stand-still by turning the crank of the Clark apparatus placed on the seat of the carriage (see engraving). It should be remarked that the result is not obtained by means of a violent shock; for the electric current is not strong enough to benumb the animal, but only sufficiently so to produce a sort of astonishment, and the disagreeable (although not painful) pricking sensation peculiar to electricity. As a complement to his electric bit, M. Defoy has recently brought out what he styles an electric "stick," and which is no less ingenious than the former. This is a riding whip containing two conducting wires, insulated from each other by leather, and terminating in two points placed perpendicular to the end of the "stick." As in the former case, the other ends are connected with a magneto-electric apparatus. If a horse is in the habit of rearing, it is only necessary to urge him with the feet, at the same time applying the points of the electric "stick" to his shoulders, when he will at once move forward with head