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FORCE AND ENERGY.

In the usual treatment of the science of mechanics and physics, three central ideas are generally made very prominent. These are force, work, and energy. The order in which they are given is an index of the treatment of the subject. Force is defined; then work is described as the exercise of force along a path through space; and, finally, energy is defined as the capacity for doing work. Nothing is more certain than the fact that a complete and working understanding of the relations of force and energy is essential to the study of mechanics and physics, and the great errors of the world of scientists and investigators have been due to ignorance or misconception of these relations. It is but a few years since the mistaken doctrine of the conservation of force was definitely abandoned for the true doctrine of the conservation of energy. Such abandonment indicated a very recent understanding of the true relations of force and energy, for the erroneous expression conservation of force is hardly yet extinct. The many attempts at the production of perpetual motion indicate a want of appreciation of the fundamental bases of science. The search is still in progress, hopeful enthusiasts refusing to accept the truth that energy is as indestructible as matter, and as impossible of creation.

But it would seem that in the threefold division force, work and energy, there is either one word too few or one word too many. Energy can be expended, and if expended, produces an exact equivalent of other energy. As fast as one quantity of energy is expended or disappears, another quantity exactly equal, though it may be of widely different form, is produced. The sum of all the energies of the universe is always equal. Now, what distinct existence can work be said to have? When energy is expended it does work; it reproduces an equal amount of energy; therefore the term work must be accepted as the synonym for the "production of energy." It would seem better to abandon the term "work," as ordinarily used, to establish the basis of mechanics, unless a synonym for the "expenditure of energy" could be found. The term "working" might supply this synonym. But the real basic terms in mechanics should be either the two, force and energy, or the four, force, energy, expenditure of energy and production of energy.

The terms work and working may be substituted for the last compound terms. As it stands now, there is a strong tendency to place energy in its definition as a sort of subsidiary to work. It should be treated as the all-important thing, and work as a convenient expression of a single one of its phases. An advanced treatment of the subject of mechanics might be based on the entire omission of the term work, making it a science of force and energy, treating work as the expression of the concrete only.

The realization of the true meaning of work makes the understanding of the impossibility of perpetual motion much clearer. No machine can produce energy or do work without an exact equivalent of energy being put into it. There is a further aspect of the subject. After all the coal is burned, after the sun has cooled down and after all the possibilities of establishing differences of temperature will have disappeared, the energy of the universe will be the same as ever, but no work will be possible, no energy can be produced. This supplement to the doctrine of the conservation of energy tells us that the available energy of the universe is tending to zero.

But as the first doctrine proscribes perpetual motion, the second opens up a possibility of a false or pseudo-perpetual motion in the conversion of unavailable into available energy. This is in the suggestion of Clerk-Maxwell, who fancifully imagines a "demon" at some future time separating the particles of matter into two divisions moving in opposite directions, without expending any energy, but simply rendering available the existing energy of all things.

If man could but separate the molecules of a gas into two sets, one as they beat to the right, the other as they beat to the left, he would be doing the act of Maxwell's demon, and the energy of the air would be made available. It would be utilized in the remixing of the molecules, and the work done would be measured by the energy abstracted from the air. The molecular motion would be lessened, or, what is the same thing, the temperature would be lowered. But the same sum of energy would exist, could we but render it available.

It is as if man started in the world with a quantity of matter or weights placed at a height and an equal quantity of weights at an equal depression below his level. Since the beginning of the human race man would be industriously raising one set of weights by lowering the other. Thus all would tend to reach the same level, and when this would be reached neither set would have any advantage of position over the other, and available energy would have reached its zero. But the same total of energy would be present, and if not zero would involve the idea that the middle plane is above the zero point. This is the same as saying that if the universe lost all its available energy it would not reach the absolute zero, where all molecu-

lar motion stops. But if the degradation of energy shall ultimately bring all matter to the absolute zero, then Maxwell's demon would find his occupation gone, and like Macaulay's New Zealander could only sit still and contemplate the ruins of the past.

THE HEAVENS IN MAY.

The interesting assemblage of planets in the evening sky will be increased in number during May by the addition of Mercury, which is in superior conjunction with the sun on the evening of the 4th. But not until the end of the month will the little planet be far enough east of the sun to be well seen. At that time it will be near Jupiter in the constellation Gemini. Early in June it will be in rather close conjunction with Jupiter.

Venus moves during May from Taurus into Gemini, passing a little more than two degrees north of Jupiter an hour before noon on the 18th. As Venus has now become so bright as to be visible to a keen eye at mid-day, it will be possible, on this occasion, to find Jupiter in the daytime with the aid of Venus, and to see them both with the aid of a strong field glass. The experiment should be made between two and three o'clock in the afternoon, when the two planets will be near the meridian. At the end of the month Venus will be near the twin stars of Gemini, Castor and Pollux. She will then have attained about one-half of her maximum brightness.

Mars, which passed Jupiter on April 25, will continue to move eastward during May, and at the end of the month will be in the eastern part of Gemini, near Venus, with which planet it will be in close conjunction on the 5th of June.

Jupiter, following the example of Mars, whom he replaced in the public eye during the latter part of the winter, is becoming less conspicuous as he draws nearer the sun, and early in June he will cease to adorn the sunset sky. Jupiter remains in Gemini, moving slowly eastward, and at the close of May will be near the third magnitude star Epsilon.

Saturn replaces Jupiter, advancing with the annual revolution of the heavens from the east. This splendid and unique planet crosses the meridian at the opening of May about 11:30 P. M., and at the end of the month about 9:30 P. M. It is in the eastern part of the constellation Virgo, near the fourth magnitude star Kappa. The only star in its neighborhood comparable in brightness with Saturn is Spica, the leading brilliant of Virgo, which shines about 12° almost directly west of the planet. Saturn's rings now present a beautiful appearance with a 3 inch or 4 inch telescope. It is the north pole of the planet that now leans earthward, and consequently it is the north side of the rings that we see. The earth is between 16° and 17° above the plane of the rings. Their major axis appears about 42° in length and their minor axis about 12°. A good 4 inch telescope is capable of showing five of Saturn's satellites, Japetus, Titan, Rhea, Dione, and Tethys. The other three, Hyperion, Enceladus and Mimas, are visible only with more powerful instruments. No one who has an opportunity to look through a telescope should fail to see Saturn. Its rings are an unceasing source of wonder, and no picture ever made of them is a perfect likeness.

Uranus is in Libra close to the fifth magnitude star Nu and about 4° east of Alpha, a star of the third magnitude. It may assist the reader in finding the place of Uranus to know that it is about 14° east-southeast of Saturn. As a telescopic object for amateurs it is hardly worth attention. Uranus is in opposition to the sun on the 8th.

Neptune is very near the fifth magnitude star Iota in Taurus, between the horns of the imaginary bull, and there, on the 19th, it will be in conjunction with Mercury. The conjunction will not be close, however, Mercury being 3½° to the north.

May opens with the moon at first quarter in Cancer. The moon falls on the evening of the 8th in Libra and attains last quarter on the afternoon of the 16th, in Aquarius. The new moon phase for May occurs in Taurus on the 24th, at 7:46 A. M., and the second occurrence of first quarter for the month happens on the morning of the 31st in Leo.

The moon pays her May visits to the planets on the following dates: To Saturn on the 7th at 8:35 P. M.; to Uranus on the 8th at 9:04 P. M.; to Neptune on the 25th at 5:53 A. M.; to Mercury on the 25th at 10:44 P. M.; to Jupiter on the 26th at 7:42 P. M.; to Venus on the 27th at 10 A. M.; to Mars on the 27th at 6 P. M.

Among objects of special interest to possessors of small telescopes that may be noted this month are a number of beautiful double stars. One of the finest of these is Gamma Virginis, a wonderful binary star whose components were so close together in 1836 that no telescope then in existence was able to separate them. Now, however, a 3 inch splits them easily, their distance being nearly 6". They are both of the third magnitude and their equality in this respect adds to the beauty of the sight. To me there is always an impression of rivalry in a double star whose components are nearly equal. Each seems to be shining its best, as if conscious of the presence of the other. A