ON ENERGY.

By Prof. Robert Stawell Ball, A.M., LL.D.

The science of Energy, which has been developed within the last twenty-five years, appears to have a grand future as intimately connected with astronomy, mechanics, light, heat, magnetism, electricity, even with life itself: it leads us back through periods, compared with which, geological time is nothing, and, looking forward, like a time telescope, points out the ultimate destiny of the universe.

Energy is the capacity of raising weights. The distinction between force and energy is that: Energy is the product of a force and a distance. The unit of energy is the energy required to overcome the unit of force through the unit of distance. Energy can be stored in a rapidly moving fly-wheel, as can be demonstrated by experiment. Energy is also stored in any body moving rapidly, as, for example, a cannon ball; energy of this kind is termed "kinetic energy." A steam-engine is a means of turning into mechanical work, a portion of the energy contained in the coal consumed in the furnace. Heat may be turned into mechanical work in other ways: for example, by a thermo-electric battery. The energy stored up in coal, gunpowder, or a compressed spring, is denominated "potential energy." Food and fuel are both forms of potential energy; but the former has to replace the wear and tear of the machine which consumes it, which the latter has not.

Energy can be changed from one form into another. The potential energy of the body may be converted into mechanical work by raising a weight, into kinetic energy, by setting a wheel in motion, heat, by friction into electricity; heat and light, by Wild's electrical machine.

A piece of zinc may be burned in a stream of oxygen. The potential energy becomes light and heat; but it might have been more slowly burned in a battery, it would thus develop electricity, which might be turned into kinetic energy by an electro-magnetic engine, or into light, sound, and heat by a Ruhmkorff's coil.

Energy is indestructible. If it disappears in one form, it is only to reappear again. A hammered nail on an anvil becomes hot; the energy which moves the hammer is transformed into heat in the nail; it is not lost. Friction appears to consume energy, but this is not so, for if proper appliances are used, sufficient heat can be collected to boil ether, or even water. Savart's apparatus is another instance; the kinetic energy of a rotating toothed wheel being, by it, transformed into sound.

Perpetual motion is impossible, because some energy is always uselessly expended in friction in every machine, and energy cannot be created. No water-wheel could pump up sufficient water to supply itself.

It has been (fallaciously) proposed to work a magneto-electric machine by a steam-engine, to decompose water with the electricity, and sustain the action of the steam-engine by heat developed by burning the oxygen and hydrogen produced by the decomposition. It would be impossible for the steam-engine to decompose enough water for the purpose.

Since, therefore, energy cannot be destroyed, and cannot be created, the quantity of energy in the universe must remain constant. This is the principle of the conservation of energy.

All the different forms of energy in the earth, whether derived from food, fuel, wind, or water, can be traced to the heat radiated from the sun. The heat is sustained in the sun by the transformation of a potential energy into heat, due to the sun's contraction. If the diameter of the sun diminished 1-10,000th part, heat sufficient to supply the present loss by radiation for 2,000 years would be produced.

The heat of the stars represents the prodigious quantity of energy. The earth has a store of potential energy due to its distance from the sun; this energy is equivalent to as much heat as would be produced by the combustion of 6,000 globes of coal, each as large as the earth. Beyond this, it has an amount of energy due to its velocity in its orbit equal to that which would be produced by the combustion of fourteen globes of coal of its own size. To this must be added a quantity of energy due to its rotation on its axis.

A period of rest, however, must at length come. The planets, since they are not rigid bodies, must ultimately fall into the sun. Heat diffuses itself, but heat cannot be turned into mechanical energy, except when transferred from a hot body to a cold body. When, therefore, by the diffusion of heat, the temperature is uniform throughout the universe, mechanical work must cease.

VELOCITY OF LIGHT.

Recently, M. Fizeau has communicated to *Les Mondes* the results of a series of very elaborate experiments, made with a view to the most accurate determination of the velocity of light. The distance between the two stations of observation, as found by triangulation, was 33,829 1 feet (about six miles), with a probable error of 0 001. The source of the ray was a jet of oxyhydric gas. Six hundred and fifty satisfactory observations were made, the mean of which gave 185,368 miles per second as the required velocity. The experiments of M Foucault to determine this same velocity, give us a result of 185,177 miles.

The formerly accepted determination of the velocity of light was that of Olaf Roemer, a Danish Astronomer, who deduced it from observations on Jupiter's satellites. The earth's orbit being concentric with that of Jupiter, and interior to it, the distance of these bodies is continually varying, the variation extending from the sum to the difference of the radii of the two orbits, making the excess of the greatest over the least distance equal to the diameter of the earth's orbit. A comparison of the eclipses of Jupiter's satellites during many successive years, showed that those which took place about opposition were observed earlier, and those about conjunction later than an average or mean time of occurrence. Connecting the observed acceleration in the one case, and retardation in the other, with the variation of Jupiter's distance below and above its average value, the difference was fully and accurately accounted for by allowing 16m. 26s. 6 for light to traverse the diameter of the earth's orbit. From these data, Roemer found the velocity of light to be about 192,000 miles per second.

It seems at first sight as if the recent and very accurate determination of M. Fizeau had demonstrated a defect in the earlier method, indicating, perhaps, some cause, connected with the acceleration and retardation of the apparent occultations of Jupiter's satellites, other than the time required for light to traverse the earth's orbit. But Captain C. W. Raymond, U. S Engineer, at present Assistant Professor of Physics at West Point, calls attention to the curious fact that by substituting in Roemer's calculation a more modern and more accurate value of the diameter of the earth's orbit, the resultant measure of the velocity of light becomes 185,344 miles per second, which agrees astonishingly with the figures of M. Fizeau. Similar experiments conducted some time ago by M. Foucault, indicated 185,177 miles per second as the velocity. This is one of the questions which will be affected by the thorough observations, to be made by trained astronomers of all nations, of the next transit of Venus. The diameter of the earth's orbit, which may be called our astronomical unit of distance, will be probably finally determined by those observations.—*Engineering and Mining Journal.*

The Rapid Growth of Trout. — "Some years since Prof. Agassiz suggested to George S. Page, Esq., of New York, President of the Oquossoc Angling Association, a means for determining approximatively the age of the famous Rangelys trout which grow to the remarkable weight of seven, eight, and even ten pounds. The mode adopted was to take a small platinum wire, pointed at one end and flattened at the other, and marked on the flat end with the weight and year. Then insert this wire in the dorsal fin, selecting a mark according with weight at the time, and return the fish to the water. In 1870, Mr. Page and others, marked and liberated some fifty trout in this way, and the practice has continued each season since. No marked fish has been captured until this season, when in a lot of trout brought back by the artist Moran, who was one of a large party who visited these waters early this month, one fish was found marked '1870, half pound,' and weighing, when captured, nearly two pounds and a quarter, showing that the trout had grown nearly one and three-quarter pounds in three years."