the air, instead of being heated by a small boiler, was made to pass through a tank which was supplied at intervals with boiling water and recharged as soon as the water cooled. The present arrangement is the result of experience derived from its predecessor.

The valve gear is simple and is fitted with a variable expansion valve under the control of the engineer, by which the cut-off can be varied from 1-10th to 5-8ths of the stroke. The link is worked by "crossed" eccentric rods, the effect of this being to prevent *any* opening of the parts when the reversing lever stands in the middle notch. By this arrangement the cylinders are, when necessary, converted into vacuum pumps and are utilized to operate the vacuum brakes attached to the cars. It has been found that when using the air expansively while running, *i. e.*, with a quick "cut-off," the expansion is sometimes so rapid that towards the end of the stroke the pressure in the cylinders is less than the external atmosphere; to obviate the loss of power which would be caused by the vacuum thus created, valves are placed in the exhaust passages, which prevent any vacuum being formed. Another feature in the engine is the existence of a suction and delivery valve at each end of both cylinders, which render it possible when going down hill, or approaching a station, to convert the cylinders themselves into "compressors," by which the pressure in the reservoirs can be increased, thus utilizing the waste energy which is usually given off in friction against the brakes. This arrangement is so successful that no other brakes are required on the engine. There are several minor points in the construction of the machine which it is not necessary to mention here ; we may, however, say in conclusion that the engine has been carefully studied in every detail.

At the trial, the engine started from 128th street with a pressure in the reservoirs of 580 lbs. per inch, and travelled as far as 42nd street, a distance of 4½ miles or thereabouts, stopping at every station, and loaded with three cars containing about 50 people. At 42nd street some switching was done, and the engine then returned to the starting place, reaching 128th street with a remaining pressure of 115 lbs.

These figures show that the train would have run from Harlem to South Ferry, the entire route of the Elevated Road. But in making any practical calculation, it must be remembered that four cars are often used instead of three, and that these four cars would often be loaded with 600 persons. This probably implies an additional weight of about thirty tons to that placed behind the Pneumatic Engine during the recent experiment.

The company must be congratulated on building a most successful engine.

UNIVERSAL ENERGY OF LIGHT.*

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Force is generally regarded as a function of mass and velocity. The greatest known velocities which can be produced by central forces are wave velocities. The greatest known wave-velocity which appears to be universally diffused is the velocity of light.

Let $v\lambda$ = velocity of light ; v_0=circular-orbital velocity at sun's surface $=\sqrt{g_0 r_0}$; v_3=Earth's mean orbital velocity ; v_r = velocity of Sun's equatorial rotation ; u_3= potential velocity of water at 0°C. $=\sqrt{2g \times 100 \times 1389.6}$ ft. ; u_4 = potential velocity of water at its maximum density ; u_5=potential velocity of water-evaporation = $\sqrt{2g \times 536.37 \times 1389.6}$ ft. ; m_0, m_3, m_5, m_6=masses of Sun, Earth, Jupiter, Saturn ; h_0=Earth's semi-axis major ; h_2=height of mean oscillatory projection due to the

combining energy of H_2O ; t_a=time of acquiring circular-orbital velocity at Laplace's limit of synchronous rotation and revolution = time of rotation ÷ 2π ; t_n = time of acquiring "nascent" or dissociative velocity at nucleal surface = ½ time of rotation = πt_a ; χ =Weber's electrochemical unit; μ=electromagnetic unit; ρ_0=total magnetic force ; ρ_3=terrestrial magnetic force ; t_0=present value of t_n at Sun's surface ; g_0=gravitating acceleration at sun's surface.

The simplicity of the relations of the universal velocity $v\lambda$ to other physical velocities, is shown in the following equations :

1. $$\frac{v\lambda}{u_3} = \frac{h_0}{h_2} = \frac{m_0}{m_3} = \frac{t_n^2}{t_a} \cdot \sqrt{\frac{\rho_0}{\rho_3}}$$

2. $$\frac{v\lambda}{v_0} = \frac{v^0}{u_4} \cdot \sqrt{2} = \frac{t_n}{t_a} \cdot \frac{v_0}{v_r}$$

3. $$\frac{v\lambda}{g_0} = t_0$$

4. $$\frac{v\lambda}{v_3} = \sqrt{\frac{m_0 m_5}{m_3}} = \frac{m_0 t_a}{m_3 t_n} \cdot \sqrt{\frac{\mu}{\chi}}$$

5. $$\frac{v_5}{u_5} = \frac{3^{\frac{1}{4}} m_0}{2 m_6} = \frac{5 \times 3^{3} m_0}{m_5}$$

The velocity of solar atmospheric rotation, at the secular mean centre of gravity of the solar system, is also equivalent to u_5.

The law of conservation of areas, in an expanding or contracting nucleus, requires that g_0 should vary inversely as t_0. Equation 3 should, therefore, hold good for all stages of solar existence, past, present and future.

· The values which satisfy the above equations are : m_0=328470 m_3 ; h_0=92476500 miles ; $v\lambda$ = 185760 miles; v_3=18.412 miles ; u_3=2986 ft. ; u_5=6916.2 ft.

The following table shows the accordance between theoretical and observed values :

	Theoretical.	Observed.
Boiling point of water........	99°.18	100°
Combining heat of H_2O......	69319	67616 to 69584*
ρ_0.............................	140.65	140 lb. pr. sq. in.
Maximum density of water....	4°.19	3°.33 to 4°.85
v_3.............................	18.31	18.41
Latent heat of steam..........	536°.374	536°.385 †
$\chi \div \mu$.........................	107.38	106.67

The velocity of light is also a factor of electromotive energy. Weber and Kohlrausch demonstrated this fact by measuring quantity of electricity ; Thomson and Maxwell, by measuring electromotive force ; Ayrton and Perry, by measuring electrostatic capacity.

Perhaps the most interesting of the above indications is the past, present and future equivalence of Sun's "nascent" velocity to the velocity of light ; the sum of the cyclical reactions of solar superficial gravitation against the actions of external gravitation, during each half-rotation, being *equivalent to the velocity of light.*

THE METAL ACTINIUM, by J. L. PHIPSON. — The author stated that he had been able to separate a new element from the pigment zinc-white. The oxide of the new element is said to be slightly soluble in caustic soda, and is soluble in ammonia and ammoniacal salts. Its color is uninfluenced by exposure to light. The sulphide of actinium is described as a pale yellow canary-colored substance ; it is insoluble in ammonium sulphide, is soluble in acetic acid, and becomes darker on exposure to the air.—*British Association*, 1881.