present be idle to speculate; it must evidently be much more complicated than that of the ordinary globular clusters, which themselves are intricate enough. Their resemblance to bodies floating on a whirlpool is, of course, likely to set imagination at work, though the conditions of such a state are impossible there. A still more tempting hypothesis might rise from considering orbital motion in a resisting medium; but all such guesses are but blind. He believes it is Lord Rosse's purpose to make drawings of all these, *based on rigorous measurement,* which may serve as evidence of change hereafter, should such occur to any perceivable extent during the ages that are yet to come. The instrument will henceforward be regularly employed by an assistant, whom Dr. Robinson has trained for the task, and on whose zeal and steadiness he can rely; and as it cannot be turned to the sky without revealing something wonderful and glorious, he is certain that it will yield an unfailing treasure to science, that it will realize the high hopes of its generous master, and be one of the proudest distinctions of his country.

April 10th, 1848.

REV. HUMPHREY LLOYD, D. D., President, in the Chair.

William Armstrong, Esq., Michael Barry, Esq., James Christopher Kenny, Esq., Rev. Joseph Fitzgerald, and Rev. William Graham, were elected Members of the Academy.

The Rev. R. V. Dixon made some remarks on the different conditions necessary to ensure a steam engine's working at "full pressure," and at "uniform pressure."

"A steam engine is said to work at 'full pressure' when the pressure of steam in the cylinder is equal to that in the boiler, or rather (as strict equality cannot exist while the machine is in motion) when the pressure of steam in the cylinder differs from that in the boiler only by a small fraction of the latter. In this case a relation exists between the velocity of the piston and the relative areas of the cylinder and steam pipe, which is easily determined. When the velocity of the engine is uniform we may assume that the pressures in the boiler and cylinder are constant, and are equal to P and P' respectively; at the same time also we shall have $av = a'v'$, a and a' being the areas of the cylinder and steam pipe, v and v' the velocities of the piston and of the steam issuing into the cylinder. Hence, the value of v'* being

$$v' = f\sqrt{\left(\frac{2g}{qw}\log\frac{n+qP}{n+qP'}\right)},$$

where f is a constant depending on the form of the steam pipe, we have

$$v = f\frac{a'}{a}\sqrt{\left(\frac{2g}{qw}\log\frac{n+qP}{n+qP'}\right)}. \qquad (1)$$

If the difference of pressures P, P' be small, we may assume that the densities vary as the pressures, which reduces (1) to

$$v = f\frac{a'}{a}\sqrt{\left(2k\log\frac{P'}{P}\right)}, \qquad (2)$$

in which $k = g \times$ the relative volume of steam under any pressure $\times$ the height of a column of water whose weight equals the same pressure.

"Further, putting $P' = P(1-n)$, n being a very small fraction whose square may be neglected, we have

$$v = f\frac{a'}{a}\sqrt{(2kn)}. \qquad (3)$$

* This is the expression for the velocity with which an elastic fluid issues through a small orifice from a vessel in which the pressure is constant on a given section at a distance from the orifice, and equal to P, and at the orifice itself also constant and $= P'$, $g = 32{\cdot}15$ and $w =$ the weight of a cubic foot of water: the units of weight, space, and time, being the pound, foot, and second. The density is expressed in terms of the pressure by De Pambour's empiric formula, $d = n + qp$.

" In order, then, that a steam engine should work with a pressure in the cylinder differing from that in the boiler only by the small fraction n of the latter, the velocity of the piston should not exceed the value determined for that particular engine by the equation (3).

" Whatever the pressures in the boiler and cylinder may be, if the velocity, and therefore the pressures, be uniform, we must have the relation

$$va\frac{l'+c}{l}=\frac{S}{n+qP'};\qquad(4)$$

which is, in fact, a statement, in algebraic form, that the volume of cylinder open for the reception of steam during each unit of time is equal to the volume of steam under the pressure P', furnished by the quantity S of water evaporated in the same time, and is one of the fundamental equations of De Pambour's Theory of the Steam Engine.

" If the engine is working at full pressure, as defined above, we may put P for P' in (4), and then

$$va\frac{l'+c}{l}=\frac{S}{n+qP};\qquad(5)$$

and substituting for P the greatest value (Π), which the boiler of a given engine will bear, we have for the lowest velocity at which it can work, without loss of steam, the equation

$$va\frac{l'+c}{l}=\frac{S}{n+q\Pi}.\qquad(6)$$

For any velocity between the highest limit given by equation (3), and the lowest given by (6), the engine will work at 'full pressure,' and the value of the pressure corresponding will be given by equation (5).

" The velocity of 'full pressure,' then, is not a *fixed* velocity, but in a given engine has assignable limits; a higher limit depending on the area of the steam pipe, and a lower, determined by the strength of the boiler.

" These obvious facts and inferences could not have escaped the notice of the Comte de Pambour, and accordingly, in his Treatise on Locomotive Engines, he has made some remarks on the connexion between the area of the steam pipe and the pressure of steam in the cylinder. In his Treatise on the Steam Engine, however,—the best, and, as far as I know, the only systematic work on the subject based on correct principles,—the author has not only omitted all reference to the effect of the magnitude of the steam pipe on the pressure of steam in the cylinder, but has made use of some expressions which might lead casual readers to form incorrect notions on this point. Thus, having determined that the maximum useful effect, with a given expansion, is obtained when the load of the engine is the greatest possible, and that this takes place when the pressure P' is greatest, he says :* ' The maximum useful effect will be given by the condition $P' = P$, or

$$v' = \frac{S}{a(n+qP)} \cdot \frac{l}{l'+c}.$$

This is, then, the velocity at which the engine must work, in order to obtain the greatest effect possible ; and the equation $P' = P$ shows reciprocally that when this velocity takes place the steam enters the cylinder at full pressure, that is, nearly at the same pressure which it had when in the boiler.' And so also in his determination of the absolute maximum of useful effect,† he supposes $\frac{l'}{l}$ variable, but always connected with the velocity by the above equation ; the velocity must, therefore, also vary, but as long as this equation is satisfied he considers the engine to work at ' full pressure.'

Now this equation is the same as equation (5) given above, and, as I have shown, is merely a statement that *if the velocity v' be within the limits assigned by equations* (3) *and* (6), the engine will work with uniform velocity, and at the full

* Page 125, English edition. † Pages 134, 135.

pressure P depending on this velocity and on the rate of expansion $\frac{l'}{l}$.

"It may be remarked, in conclusion, that for the completeness of the theory, and to show the connexion between all the variables of the problem, we should add equation (1) to the two given by the Comte de Pambour, and thus, between the four quantities, v, R, P', P, we will have, in the general case, the three following equations, leaving one of those quantities indeterminate.

$$\frac{l'}{l} + \frac{l'+c}{l}\log\frac{l+c}{l'+c} = \frac{n+qR}{n+qP'} \qquad (\text{A})$$

$$va\frac{l'+c}{l} = \frac{S}{n+qP'} \qquad (\text{B})$$

$$v = f\frac{a'}{a}\sqrt{\left(\frac{2g}{qw}\log\frac{n+qP}{n+qP'}\right)}. \qquad (\text{C})$$

Professor Harrison made the following remarks on the Larynx, Trachea, and Œsophagus of the Elephant:

"My principal object in the present communication is to direct attention to a particular muscle in the elephant, connecting the back of the trachea to the fore part of the œsophagus, and to which I would give the name of 'trachea-œsophageal muscle.' As I do not find any mention of this in Camper's works, or in the Encyclopedie Methodique, or in the article 'Pacchydermata,' by R. Jones, in Todd's Cyclopedia of Anatomy, I conclude it has not been observed by former anatomists.

"My attention was accidentally directed to it in the course of the dissection of the thoracic viscera. When removing the lungs and heart, I remarked an unusually close connexion to exist between the trachea and œsophagus, and which, on examination, I found depended on a short, thick muscle, which extended from the back part of the bifurcation of the trachea to the fore part of the œsophagus, and along which the fibres