

was the reason of its fracture, and it was certain that a constant change was going on in all manufactured iron. At the Thames Tunnel, the "fleeting bars," used as levers for turning the large screws for forcing forward the shield, never lasted longer than three or four weeks, although they were very strong, and were made from the best materials by careful smiths. They were only used occasionally, and then without any concussion, having only the power of eight men exerted upon them: yet they broke constantly, and the fracture exhibited a bright crystalized appearance. It was found at last, that in order to give them duration, they should be left rough, and not hammered much in working.

Mr. Newton observed, that full ten years since, Dr. Church had used hollow axles for his experimental steam coach on common roads, being convinced of their superiority.

Mr. Fox was an advocate for the hollow axles, but he did not consider the present experiments quite conclusive, as there were differences in the relative dimensions of the axles experimented upon; he would suggest another series of trials, upon a larger number of axles, as the subject was one of great importance, not only to manufacturers, but to the public, whose safety in travelling depended upon the goodness of the axles under the carriages. He had used upwards of 5000 axles made by the Patent Axle Company, and had made many experiments by breaking them; the average result was equal to that quoted by Mr. York. He agreed in the danger arising from overheating iron, as also from over-hammering it, and for some time past he had caused all the axles to be made 6 inches longer than was necessary, in order to cut 3 inches off each end, to try the quality and the appearance of the fracture of the iron.

The President remarked, that there could not exist a doubt as to the greater strength of a hollow axle, as compared with a solid one; both containing the same weight of material; the principal question to be considered was that of vibration, and its effect upon the cohesive strength of the metal, whether the action upon the particles was more irregular in the solid body, and more distributed in the hollow one; he recommended this investigation to some of the mathematicians who were present; the result of their inquiries might materially aid in the development of truth from the practical experiments.—[*Trans. Inst. Civil Eng.*]

Lond. Journ. Arts & Scien.

Flying Machines. By JOHN BISHOP.

We are not destitute of data for estimating the force which is called into action in order to sustain, and keep in motion in the air, bodies, more or less heavy; sufficient has, at least, been done to enable us to form some conjecture respecting the probability of the success of Mr. Henson's machine. An elaborate memoir, on this subject, by M. Chabrier, has been published by the Institute of France, in which will be found a profound mathematical inquiry into the conditions necessary for the movement of machines in the air. In Dr. Todd's Cyclo-

pædia of Anatomy and Physiology, part 23, article *Motion*, I have contributed a number of illustrations, by ascertaining the weight of various insects, bats, and birds, and the amount of surface in each respectively. I have also computed the number of strokes made in a second by the wings of the rook and the pigeon during flight. It appears that the average weight of the pigeon is 4347.344 grains; that of the rook 4170.25 grains; and that of the canary 229 grains; whilst the areas of their wings are respectively 0.6198, 1.11, and 0.054 of a square foot. Hence, we see that the areas of the wings of birds do not vary as their weight; and that the rook has nearly half a pound weight to the square foot, and the pigeon one pound; the former making two, the latter three, effective strokes of the wings in a second. The weight of the former is, therefore, greater, that of the latter less, in proportion to the surface presented to the wind, than in Mr. Henson's machine.

It must, however, be borne in mind, that in this machine the surface presented to the wind has no motion like the wings of birds, neither does the machine possess the power of ascending vertically. In birds, on the contrary, according to Borelli,* the power of the muscles which move the wings, compared with their weight, is more than 10,000 to 1; whilst their mass, compared with the muscles moving the legs, is as 3 to 1. We agree with M. Chabrier, that the amount of force requisite for ærial progression is so enormous, owing to the rarity of the atmosphere, that it would be impossible for a man to sustain himself in the air by his muscular strength alone, in any manner, in which he is capable of applying it. For example, it is calculated that a man can raise 13.25 lbs. avoirdupois, to a height of 3.25 feet in a second, and that he can continue this exertion for eight hours in a day. In that space of time he will, therefore, exert a force capable of raising 381,600 lbs. to a height of 3.25 feet, or 45,700 lbs. to a height of 26 feet, which, according to M. Chabrier, is the height to which the swallow would raise itself in a second of time, by the force which it is obliged to exert in order to sustain itself in the air. Now, if we suppose the conditions, necessary for flight in man, to be the same as in birds, and that a man whose weight is 150 lbs., could concentrate the muscular power of a day's labor into as short a period as the accomplishment of the object required, the time, t , during which he would be enabled to support himself in the air would be,

$$150 t = 47,700;$$

$$\text{hence, } t = \frac{47700}{150} = 318'', \text{ or about five minutes.}$$

The surface of the wings in the rook and the pigeon when expanded, will not support them stationary in the air, unless they move with rapidity; for when the wings of the rook are expanded motionless in the air, the bird descends by its own gravity with considerable velocity; and as it has a greater surface, compared to its weight, than Mr. Henson's machine, it follows that the latter would be precipitated

* De Motu Animalium.

to the earth with still greater velocity, should the propelling apparatus get out of order in its transit through the air.

It appears by M. Chabrier's analysis, that the quantity of force expended to keep a body, whose weight is W , stationary in the air, (all other conditions being supposed the same,) is as $\sqrt{W^3}$ directly, and $\sqrt{\text{density of the air}}$ inversely. I have, however, elsewhere shown that the quantity of force employed for this purpose, by some birds, is rather less than that here stated.

Lond. Mech. Mag.

Description of Lieutenant D. Rankine's Spring Contractor. By
WM. JOHN MACQUORN RANKINE, Assoc. Inst. C. E.

This paper describes a contrivance for suiting the action of the springs of railway carriages to variable loads, so as to give the proper ease of motion to a carriage when heavily laden, and at the same time to be sufficiently flexible for light loads. Its effect is to make the strength and stiffness of the spring increase in proportion to the load placed upon it. Each extremity of the spring, instead of supporting a shackle, or roller, as in the usual construction, carries a small convex plate of cast-iron. The form and position of this plate are so adjusted, that when the carriage is unloaded, it bears on the extreme end of the spring, thus allowing it to exert the greatest amount of flexibility; but as the plate is convex, the more the load increases, and the further the ends of the spring descend, the nearer does the point of bearing of the plate upon the spring, approach to the centre, or fulcrum, so that the convex plate, or contractor, tends to diminish the virtual length of the spring in proportion to the load, the result of which is to increase the strength of the spring in the inverse ratio of its virtual length, and its stiffness in the inverse ratio of the cube of the same quantity.

The author then gives in a tabular form, the details and the results of some experiments made on springs of this description, which are similar to those now in use on the Edinburgh and Dalkeith Railway. The springs were 4 feet long, each consisting of ten plates, each $\frac{1}{2}$ inch thick, and $2\frac{3}{4}$ inches broad. The contractors were cast with a radius of $12\frac{1}{4}$ inches, and so constructed as not to act until the load on each spring exceeded 10 cwt., and with a load of 30 cwt., they should have contracted the distance between the bearing points to 3 feet 4 inches, instead of four feet; by this means the strength of the spring was increased in the ratio of 6 to 5, and its stiffness in the ratio of 216 to 125.*

The advantages stated to be derived from the use of these springs on the Edinburgh and Dalkeith Railway, and other lines, are—That

* Since this communication was made, contractors of great length, and increased radius of curvature, have been applied, so as to produce a contraction of 6 inches at each end of the spring when fully loaded, which increases the strength in the ratio of 4 : 3, and the stiffness in that of 64 : 27. The details of the construction of these contractors, with a drawing of them, as applied to the springs of the carriages on the Edinburgh and Dalkeith Railway, are given in the addendum to the original paper.