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THE MEASUREMENT OF POWER.

Work is defined to be force or pressure acting through space, and it is usually expressed in foot pounds. Thus if a resistance of 40 pounds is overcome for a distance of 10 feet, we say that the amount of work is 400 foot pounds.

The power of a machine is the amount of work done in a given time. The unit of time for a machine is usually taken, in this country and in England, as one minute, and the unit of work, as 33,000 pounds raised 1 foot high, or 1 pound raised 33,000 feet high—the unit of power in this case being called one horse power. The French unit of power is called the *force de cheval,* and is equivalent to a power capable of raising 4,500 kilogrammes 1 meter high in a minute, or 32,549 pounds 1 foot high in a minute. Hence the French unit of measure for the power of a machine is about $\frac{1}{73}$ less than the English.

The simplest way to test the power of a steam engine is to see how high it will raise a given weight in a minute, and this is readily accomplished by means of the friction brake, often called the Prony brake, from the name of the inventor. The fly wheel of the engine is covered by a strap, which has a lever attached to it, on which weights are hung. By tightening this strap, the friction between it and the wheel may be made to take all the useful power of the engine, the amount being measured by the number of pounds in the weight and the number of revolutions of the engine per minute. Suppose, for instance, that the engine makes 100 revolutions a minute, and maintains the lever of the brake horizontal when it has a weight of 50 pounds attached at a point that would move a distance of 30 feet in each revolution of the engine, if it were free to revolve. Then the useful work of the engine per minute will be $50 \times 30 \times 100 = 150,000$ foot pounds, which is equal to $150,000 \div 33,000 = 4{\cdot}5 +$ horse power. The steam engine indicator can also be used to determine the power exerted by the engine. By means of an indicator diagram, the mean pressure exerted on the piston during one stroke can be ascertained, and the horse power of the engine can be calculated by the following formula: Horse power = mean pressure × effective area of piston in inches × twice length of stroke in feet × number of revolutions per minute ÷ 33,000.

The indicated horse power will always be greater than the amount determined by the brake, because by the use of the indicator we obtain the total power exerted by the engine, including that necessary to overcome the friction of the moving parts and other prejudicial resistances. The difference between the indicated and effective horse power varies in different machines from 10 to 50 per cent of the whole power exerted by the engine. By throwing off all the work from the engine and taking a friction diagram, the amount of power required to overcome prejudicial resistances can be approximately determined. It must be evident, however, that the test with the brake is the most accurate, as the friction of the moving parts, which increases with the pressure, is greater when the engine is doing useful work.

In practice, the friction brake must be constructed with efficient means for cooling, as a great amount of heat is developed by the friction between the fly wheel and the strap. The most perfect form of brake is that used by the Royal Agricultural Society of England in their tests of portable engines. This is arranged with compensating levers, which ease or tighten on the friction strap automatically, keeping the lever which carries the weight always horizontal. With this form of brake, all the power exerted by the engine is overcome by friction. Cases frequently occur in which it is desirable to measure the amount of power transmitted by a shaft or pulley, and here the friction brake cannot be employed. Recourse must then be had to transmitting dynamometers, which measure the power exerted by registering on a scale the amount of force necessary to keep the pulley from turning on the shaft, or to keep the shaft from turning in its coupling. In the use of a transmitting dynamometer, the pulley is loosened on the shaft, and is clamped to a portion of the dynamometer that is securely fixed, the connection being made by weights, springs, or levers. In transmitting the power, the pulley will turn on the shaft until the tension of the spring or resistance of the weight is equal to the force necessary to drive the machinery; and the amonnt of this force being registered on a scale, the calculation for the power is made in the same manner as with the friction brake. None of the transmitting dynamometers, in use at present, are free from objections; and they require frequent testing, and very careful application to make the results reliable. For these reasons, the indicator and friction brake are generally employed, when their use is practicable. In a future article, we may have some remarks to make about the importance, to owners and users of steam power, of frequent and accurate tests.

THE COMING PAVEMENT.

Recently there has been laid down on Fifth avenue, at its intersection with Broadway in this city (24th street), a trial specimen of the new Grahamite asphalt pavement. The example in question covers the street for half a block, and is placed just where it will receive the severest tests, from the wheels of omnibuses, ice carts, and throngs of vehicles of all sorts. If the new pavement can stand the racket here, no other test will be required. So enormous is the travel in this part of the city that the cross-walks, made of thick granite slabs, are soon grooved with ruts, cut by the wheels of heavy vehicles.

The new asphalt pavement is composed of a material termed Grahamite, found in West Virginia, and is alleged to possess more cohesion, tenacity, and elasticity than the famed *Val de Travers* asphalt, so extensively used for paving purposes in Paris and other European cities.

Grahamite does not fuse until it reaches 800° Fah., while the ordinary asphalts generally fuse below the heat of boiling water. The higher fusing point is due to the large quantity of asphaltene which the Grahamite contains. The Grahamite pavement will therefore remain hard and firm under the hottest natural temperatures, while the ordinary asphalt pavements under the same circumstances became softened and disintegrated. The Grahamite pavement possesses a high degree of elasticity, which affords great relief to the feet of horses and prevents the wear of vehicles; it is also so tenacious and hard that it will stand the heaviest blows from a sledge, only suffering compression at the surface. We have seen this test repeatedly applied, and have further noticed that the heaviest vehicles roll over it without making the slightest impression. It presents an even surface and forms, in every outward respect, a most admirable pavement. If the example now under trial shall prove, on the lapse of time, to be as really good as it now is, we have no doubt that our citizens will be glad to give it a general introduction. Wood pavements are a failure, and granite blocks are dreadful to travel upon. It may be that Grahamite is the coming pavement.

The pavement question deeply concerns every city and town in the land; and if anybody wants a subject to study upon, with a view to devising improvements, here is a grand one.

LETTERS FROM COMMISSIONER THURSTON.

Among the select number of scientific experts appointed by the President to examine and report upon the different departments of the Great Exposition was Professor R. H. Thurston, of the Stevens Institute of Technology, Hoboken, N. J. On the eve of his departure, we requested him, if time permitted, to favor the readers of the SCIENTIFIC AMERICAN with an occasional letter, giving an outline view of the most interesting matters that might come under his observation, and he kindly consented to do so.

We have the pleasure of presenting in another column the first of Professor Thurston's communications, which contains a variety of interesting matter, including an account of preceding expositions, indicating also some of the points to which his attention will be specially directed during the present World's Fair at Vienna.

In all that relates to practical science, especially the mechanical branches, Professor Thurston is eminently qualified as a judge and observer. He will enjoy the best opportunities for obtaining information, and his letters will have a peculiar value.

THE DIGESTIVE APPARATUS.

In a former article, we described the digestive channel from the mouth to the stomach. We will now trace the metamorphosis of the food into living tissue, which takes place after the food has reached its proper receptacle, the stomach.

The main agent in this process is the gastric juice, of which a healthy human stomach secretes not less than about 70 ounces ($4\frac{3}{8}$ pints) every day. As the muscles are those portions of the body most subject to waste, every motion of a limb requiring a consumption of fibrin, a large portion of gastric juice is consumed in making fibrin for muscular repair; it has been ascertained that, in average muscular action, the consumption of fibrin is about 60 grains per day, requiring nearly 60 ounces of gastric juice for the formation of new substance to replace it. The food, after reaching the stomach, forms a kind of pulpy mass, subject to an intermittent slow rotation by the alternate contraction of the fibers of the exterior muscular coat; in this, the respiratory movements assist greatly. If the contents contain too much liquid, a large portion of this is directly absorbed, by endosmose of the coats of the stomach, and enters the circulation at once, so that the mass remaining may have the consistency proper for the performance of this rotatory motion. The exterior portions of this pulpy mass, which have undergone complete treatment by passage and friction along the interior coat of the stomach, ooze out into the intestines through a valve (called the *pyloric*) in a semi-fluid state, apparently homogeneous, called *chyme.* Its formation requires from one to four hours, while the muscular movement of the intestine propels it forward to the duodenum, where it is mixed with the pancreatic juice secreted by the pancreas, the enteric juice secreted by Brunner's glands, and the bile secreted by the liver.

Several erroneous theories formerly prevailed in regard to the digestive power of the stomach. One was that digestion was simply a mechanical operation, and that the food was ground up fine; but this was disproved by inclosing meat in small hollow silver balls, full of holes, attaching them to a string, and causing them to be swallowed by a dog; when, after a few hours, they were withdrawn, the meat was found fully digested, which could not be due to any grinding power, as it was fully protected against this. The other theory was that digestion was due to nervous agency, because it was much interfered with when the pneumogastric nerve was divided; but then it was proved that this simply paralyzed the motion of the stomach, and prevented the rotation and expulsion of the food, while the secretion of gastric juice and its action on the food was in no way interfered with. A third theory was that the food was vitalized in the stomach; that is, by means of some mysterious change, it was made to share in the vitality of that organ; but such a theory is highly unscientific, and nothing more or less than an attempt to explain the mystery by a word of obscure meaning, while it does not elucidate anything. It must be considered that even when the food is inside the stomach it is, anatomically speaking, yet outside the body or system, and cannot become part of the system before contact action takes place; and this action is chemical. The chemical theory of digestion, then, is now accepted as the true one; and it is corroborated by the fact that physiological chemists have succeeded in perfect artificial imitation of digestion, between which and the natural digestion there is no difference whatever.

Careful investigations on animals, and even on men who by accident had fistulous openings which gave access to their digestive channels, have proved that all substances are not digested in the stomach itself: that, for instance, nitrogenized food is not fully digested by the gastric juice, but chiefly by the intestinal juice, through the whole length of the small intestine; and that fat is not digested at all in the stomach, but that its digestion only begins when this intestine is reached; this has been called the calorifacient digestion, as it is directed to the heat-making portion of the food, and has for final result the keeping up the animal heat of the body. The length of this portion of the digestive apparatus is about 20 feet, and its surface some 3,500 square inches, being much greater than those portions of the digestive channel devoted to nutrition. The latest view in regard to the calorifacient digestion is that of M. Bernard, who has published experimental evidence proving that the digestion of fats consists simply in bringing them into the condition of an emulsion, by means of the pancreatic juice; and so they enter into the circulation of the blood and, while there, are in a continuous state of slow combustion, combining with the free oxygen which the blood has absorbed in the lungs, and is always carrying through the system.

The emulsion of the fats with the pancreatic juice, mixing with the chyme from the stomach and other ingredients, is absorbed by the ends of the lacteals, called *villi,* which are delicate tubes with which the interior of the intestines are lined, and which convey the metamorphosed substances of the food, now called *chyle,* through the mesenteric glands into the lacteal tube, which discharges the chyle upward into the veins just before they discharge their blood into the lungs.

The functions of the lacteals and *villi,* which are of such minuteness that in every square inch there are some 10,000