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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 $150{,}000 \div 33{,}000 = 4·5 +$ 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 of them, are coincident with the operation of the lymphatics. We have here two separate systems, the lacteal and lymphatic, which ramify from the intestines all over the body, and of which the anatomical and physiological actions and relations are at present an important subject of investigation for modern biologists, and not yet fully understood.

It is evident from the preceding that the blood vessels, which have received the material from the digestive apparatus, contain two distinct liquids, the original venous blood and the chyle; this mixture makes its way through the portal vein to the liver, which is a double structure, of which one function is to cause this mixture to undergo an enormous change, consisting in the formation of young blood cells, and the other is the economizing of the mineral ingredients of the disintegrated blood cells, which are also eliminated by the liver and of which iron is the principal ingredient.

The above outline may serve to give the general reader an idea of the highly elaborate complexity of the diverse operations belonging to the mysterious process by which foreign organisms are changed into the living tissues of our bodies, which tissues, by interstitial repair, take the place of the old ones; they do this so thoroughly that we may safely assert that, in the course of only a few years. not a single material atom is left of those of which the body originally was made up. In order to comprehend the truth of this, we have only to consider that the average amount of solid food required for each human being is 800 lbs. per year, of drink 1,500 lbs. and of oxygen, consumed from the air, 800 lbs., a total of 3,100 lbs., surpassing the weight of the body more than 20 times. The most wonderful fact to contemplate is that, with all this continual change of the material of which our bodies consist, we do not lose our identity.

MORDANTS FOR ANILINE COLORS.

While aniline dyes are remarkable for the ease with which they attach themselves to animal fiber, whether silk or wool, they are difficult to fix upon cottons and vegetable fiber in general. For this purpose albumen, the bichromates and other mordants have been used or recommended. The number of such mordants is not a small one; but the important question at present is which can be employed to the greatest advantage, and which will produce the most beautiful and cheapest colors. This cannot be answered by a series of experiments conducted on a small scale, but only by operating upon large quantities and in a practical workshop. The dyer in fine colors will not usually have an opportunity to decide which is the most suitable mordant for cottons. In this question, the value of the bath after the operation and its capability of being turned to account must be considered, and in all calculations, its value must be deducted from the total cost of the materials employed.

To discuss at this time all the different methods employed in fixing aniline colors would lead us too far; almost all have been superseded by the methods in which tannin is employed. This is especially adapted to fuchsin and iodine green. Both of these dyes produce, with tannin, brilliant colored compounds which are totally insoluble, so that tannin most completely fulfils the ends required of a mordant. Tannin is, however, quite expensive, and hence we must seek some substitute which either renders the use of tannin entirely unnecessary or at least makes a saving in its use. The substances previously suggested, such as oleic acid or stearic acid, do not sufficiently fulfil the requirements, and it seems probable that a substitute for tannin, which shall entirely replace it, will be difficult to find. A long series of experiments on a large scale have lead to the conviction that tannin, either pure or in sumach, is, in the mean time, still indispensable.

A German, named Austerlitz, has recently observed that a considerable saving of tannin can be effected by combining it with glue before using it, so as to employ both glue and tannin simultaneously as mordant. Under these circumstances, much less tannin is required to produce a given shade with fuchsin, iodine green or any other aniline color; in fact, the same results may be obtained with half the quantity of tannin required when no glue is used. Austerlitz says: "I have established this by a series of experiments on a small scale using weighed quantities of tannin with varying quantities of glue. A piece of cotton goods was first mordanted in a bath of tannic acid, and then cut in two, one half being drawn through a weak solution of glue or gelatin, the other immersed directly in a dye bath of known concentration at a given temperature. The half which had been through the glue bath was then dyed in a bath of precisely the same sort, and the two samples compared. The cotton on which glue had been employed was far more thoroughly dyed and of a deeper shade. It was also proved that the tannic acid bath might be much weaker, if followed by a glue bath, than when used alone. The amount of tannin saved in this way is not small.

By gradually diluting one of the tannin solutions and continuing the series of parallel experiments with tannin and glue and with tannin alone, a point is finally reached where both methods produce the same shade. When this point is arrived at, a comparison of the concentration of the two tannin baths will show how much is saved. This quantity, of course, depends greatly upon the quality of the tannin, so that my experiments have not given a result which can be expressed in figures. Samples from different sources gave different results, so that in some cases more was saved by the glue bath, in others, less."

The cause of these phenomena have not yet been ascertained but it is probable that a compound of tannin and glue is formed, which has an action upon aniline different from that of tannin alone.

FISH CULTURE BY FARMERS.

Why should not farmers and others raise fish for the market and for their domestic uses, as well as cattle, fowls or any other living stock? For so staple and healthy an article of food, it seems as absurd to be dependent upon chance capture in a wild state as it would be to rely for our poultry upon the fortune of the hunter or for our vegetable supply upon the finding of suitable esculents in localities in which a knowledge of botany may tell us they ought to grow. The efforts of the fish commissioners in this and other parts of the country, in stocking the waters with the spawn of valuable species of fish, will undoubtedly largely increase the numbers of the finny denizens of our rivers and streams; but the labor of securing an abundant and readily obtainable supply is thus only begun, and it seems to us that it may be continued by every dweller in the rural districts having the simple facilities requisite for the construction and maintenance of suitable fish receptacles.

Artificial incubation and the stocking of private ponds are of course no novel idea. History tells us of the vast sums expended for such purposes during the decline of the Roman empire; and pisciculture, especially in the monasteries, seems to have flourished through the middle ages. The success which has attended all modern efforts in a similar direction, even in the propagation of the trout and other delicate species, leaves little doubt but that, at a very moderate outlay of time and money, every farmer could provide himself with a well stocked pond, which he would find a constant source of valuable remuneration.

Dr. J. H. Slack, the New Jersey Commissioner of Fisheries, writes to the *Tribune* a letter containing many useful hints relating to this subject. Referring to the preparation of the ponds, he says that two points must not be overlooked: proper proportions of the banks and freedom from surface water. For the former, with ordinary loam, the following proportions will be found correct: Let the base of the tank equal three times its hight, and let the width of the top equal the hight. Thus, if the tank be 10 feet high the base should be 30 feet and the width at the top 10 feet. The sluices and overflow should be made of stone laid in cement. Wood, it is stated, will rot very rapidly and prove of no value. The services of a competent engineer may be employed to advantage, and the money expended for such supervision will save much trouble and vexation. Surface water is a fertile source of trouble, as it carries with it brush and leaves, which clog the screens, allowing the contents to overflow and permitting the escape of the fishes. In most cases, a series of ditches, entirely surrounding the ponds, will carry off the surface water, a gate being placed at the head of the ponds with an opening only allowing as much water to enter as can be readily conducted away. At the sluice gates screens of wire gauze must be placed to prevent the egress of the fish. These should be made of galvanized wire if of large mesh, and of copper if fine. A screen of coarser mesh, placed a few inches up stream from the fish screen, will arrest much of the floating trash and prevent clogging. This second screen, called the leaf screen, should be placed at an angle of about 60° that a greater surface may be exposed to the water.

As regards stocking the tanks, it can hardly be expected that every farmer can enter into the careful operations of trout culture, but there are plenty of other varieties of fish suitable for food which may be easily and profitably reared. The ordinary cat fish (*pimelodus*) will thrive and breed in almost stagnant water, and is hardy and enduring. The female takes care of her young, which, for some weeks after they are hatched, follow her about as chickens do a hen. For large ponds, through which a gentle current can be made to flow, the best fish for the south is the southern bass (*grystes salmoides.*) It has a variety of names and is known also as the yellow and black bass, trout, chub, and growler. The adult fish is of a greenish brown color with a bluish black spot upon the gill, the young having in place of the spot from two to four longitudinal bars; the back fin is spinous and high, and the tail is similar to that of the trout. Besides the above two varieties mentioned as examples, there are scores equally valuable as food, some indigenous to northern, others to southern waters, which will probably suggest themselves to our readers interested in the subject.

The temperature of the water in the tank is an important matter, as fishes respire not water but air mingled with water. At the temperature of 50°, six cubic inches of air are contained in each gallon of aerated water, while at 212° none is present. With a supply of 1,000 gallons per minute at a temperature of 50°, fish could be maintained in a tank of about 8,000 cubic feet sufficient for a small village.

If the pond be well supplied with aquatic insects and plants, the fishes will need no food; but generally overstocking is the case and hence a certain quantity is required. Any kind of animal food, cooked or uncooked, is suitable; the entrails of fowls, lights of beef, oxen and hogs, if thrown in in small pieces, will be eaten with avidity. Curd or "smear kase" should only be given with animal food, being apt to cause disease. For the small fry of trout, the larvæ of the common mosquito are stated to form excellent nutriment, a better utilization, by the way, of that tormenting insect than the Yankee project of capturing them in large quantities and using their bodies as manure. It is estimated that about two barrels of rain water will be required for each thousand fry, the insects being strained out from time to time as fast as they are developed, and thrown into the trout pond.

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A SHOWER of frogs, which darkened the air and covered the ground for a long distance, is the reported result of a recent rain storm at Kansas city, Mo.

THE RECENT ARCTIC EXPEDITION.

Secretary Robeson's report of the official investigation regarding the Polaris expedition, based upon the testimony of the survivors rescued from the ice floe, has at length been given to the public. As far as the record of the voyage extends, the account is substantially the same as that already published in detail in our columns. Considerable information, however, has been elicited regarding incidental topics and that bearing upon the mysterious portion of the recital, notably the death of Captain Hall; while that relating to the separation of ship and crew is of especial importance and interest.

The circumstances attending the decease of the commander are fully detailed, and as far as possible the statements of the witnesses reconciled and carefully compared. From all the testimony, the examining officials are inclined to reject the poisoning theory, so eagerly grasped by sensational journals, and arrive at the unanimous opinion that the death was due to natural causes. This view is qualified by the statement that none of the survivors are capable of giving an accurate account of Captain Hall's symptoms, nor of his last illness, and consequently the true state of the case must remain indefinite until the return of the Polaris. There seems little doubt but that the breaking adrift of the ship was purely the result of accident. The vessel was suddenly beset by a tremendous pressure of ice, which was driven against her from the southward, throwing her on her beam ends. To ease her, the provisions, stores, etc., were being removed when, during the darkness of the night and in a fierce gale, she parted her hawsers and disappeared. The sighting of the Polaris on the next day and her non-response to the signals of the abandoned crew, even when, from the distance intervening, they must have been clearly seen, are carefully considered. It is believed that, from a dispassionate point of view, the apparent indifference of those aboard must be ascribed to both inability and caution. The vessel had been so roughly handled the night before that both captain and crew might readily believe she would be lost; hence the removal of articles to the floe was attempted. Then when she broke adrift, her steam pipes, valves and connection were solid; and she was for hours without steam, unmanageable amid the floating ice. Moreover she was leaking badly and totally destitute of boats, so that it appears to have been the duty of the commander, Buddington, to get her in a place of safety, such as was the shelter of Northumberland Island, as speedily as possible. Furthermore, he knew that the ice party had boats and consequently could have believed their safety assured; and at all events, whatever his doubts might have been, a severe gale decided the question, driving the ice floe out of sight of ship and land. From this array of considerations, the final judgment is reached that the entire circumstances of the separation were accidental and unavoidable.

The Polaris, it is stated, had a broken stem and was leaky. She had plenty of provisions but not much coal, and probably remained in winter quarters at Northumberland Island. There is a difference of opinion as to whether she will be able to reach Upernavik or Disco under sail if she gets free this season, and it is believed that she will need assistance to escape from the ice.

The scientific results of the expedition are better than first imagined. The records of the astronomical, meteorological, magnetical, tidal and other departments are extremely full, and extensive collections of objects of natural history have been made. Specimens of drift wood were picked up near the shores of Newman's Bay, in which walnut, ash, and pine were recognized. The dip of the needle amounted to 45° and its duration to 96°, being less than at Port Foulke and Rensselaer Harbor, as given by Drs. Kane and Hayes. Auroras were frequent but not brilliant, consisting sometimes of one arch and sometimes of several. Streamers were quite rare and shooting stars almost constantly visible. The average of the rise and fall of the tide was about 5½ feet, and the greatest depth of water noted 100 fathoms. The existence of a constant current southward was also noted, its rapidity varying with the season and locality. The winter temperature was found much milder than was anticipated, the minimum being 58° below zero in January, though March proved to be the coldest month.

The open polar sea of Kane and Hayes was found to be a sound of considerable extent, and, it is believed, communicates with Francis Joseph Sound, and thus defines the northern limit of Greenland. Its length was not ascertained.

Pursuant to the recommendations of the investigating committee, the Secretary of the Navy has completed the purchase of the sealing steamer Tigress, the vessel which rescued the party on the ice field, and has ordered her prompt fitting out for a voyage in search of the Polaris. The Tigress is constructed especially for encountering the heavy ice of the arctic regions, and will be equipped in the most thorough manner so as to be ready for sea by the early part of July. She will be commanded by Commander James A. Greer, a well known officer of the navy. The Juniata, another naval vessel, has been got in readiness with the greatest rapidity and has sailed for Disco to carry supplies of coal and provisions for the Tigress, and also to seek information regarding the Polaris. The ship was fitted out at the navy yard in Brooklyn, and is heavily sheathed with iron. It is expected that she will return during the autumn, bringing the latest news and leaving the Tigress to penetrate to Northumberland Island.

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"THE PIG IRONISTS IN COUNCIL" is the heading of a report, in the New York *Herald*, of the proceedings of a convention of gentlemen engaged in the iron trade, lately assembled at Cleveland, O. Rather a scaly sort of irony, that.