XI. Description and use of the dynanometer, or instrument for ascertaining the relative strength of men and animals

Cit. Regnier

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When the mixture has boiled half an hour, pour it into a flat vessel, in order that the charcoal may subside to the bottom ; then pour off the liquid, and place it over the fire once more, that the superfluous water may evaporate, and to give to the molasses their former consistence. Twenty-four pounds of molasses will produce twenty-four pounds of syrup.

This method has been employed on a large scale with the happiest effects ; the molasses become sensibly milder, and can be employed in many articles of food ; though in dishes where milk is used, or for cordials mixed with spices, sugar is to be preferred.

XI. *Description and Use of the Dynamometer, or Instrument for ascertaining the relative Strength of Men and Animals.*
Invented by Cit. REGNIER. From Journal de l'Ecole Polytechnique, Vol. II. 6th Year.

WHEN Sanctorius invented his balance, he taught us what we lose by insensible perspiration ; and no one, without this discovery, would perhaps ever have imagined that the matter thrown out from the body is more than half what we receive as nourishment. Knowledge no less important might be acquired, had we the easy means of ascertaining, in a comparative manner, our relative strengths at the different periods of life, and in different states of health. Buffon and Gueneau, who had some excellent ideas on this subject, requested me to endeavour to invent a portable machine, which, by an easy and simple mechanism, might conduct to a solution of this question, on which they were then engaged. These philosophers were acquainted with that invented by Graham, and improved by Dr. Desaguliers, at London ; but this machine, constructed of wooden-work, was too bulky and heavy to be portable ; and, besides, to make experiments on the different parts of the body, several machines

machines were necessary, each suited to the part required to be tried. They were acquainted also with the dynamometer of Cit. Leroy of the Academy of Sciences at Paris. It consisted of a metal tube ten or twelve inches in length, placed vertically on a foot like that of a candlestick, and containing in the inside a spiral spring, having above it a graduated shank terminating in a globe. This shank, together with the spring, sunk into the tube in proportion to the weight acting upon it, and thus pointed out, in degrees, the strength of the person who pressed on the ball with his hand.

This instrument, though ingenious, did not appear sufficient, however, to Buffon and Gueneau; for they wished not merely to ascertain the muscular force of a finger or hand, but to estimate that of each limb separately, and of all the parts of the body. I shall not here give an account of the attempts I made to fulfil the wishes of these two philosophers, but only observe, that in the course of my experiments I had reason to be convinced that the construction of the instrument was not so easy as might have been expected. Besides the use which an enlightened naturalist may make of this machine, it may be possible to apply it to many other important purposes. For example, it may be employed with advantage to determine the strength of draught cattle; and, above all, to try that of horses, and compare it with the strength of other animals. It may serve to make known how far the assistance of well-constructed wheels may favour the movement of a carriage, and what is its *vis inertiae* in proportion to the load. We might appreciate by it, also, what resistance the slope of a mountain opposes to a carriage, and be able to judge whether a carriage is sufficiently loaded in proportion to the number of horses that are to be yoked to it. In the arts, it may be applied to machines of which we wish to ascertain the resistance, and when we are desirous to calculate the moving force that ought to be adapted to them. It may serve, also

as a Roman balance to weigh burdens. In short, nothing would be more easy than to convert it into an anemometer, to discover the absolute force of the wind, by fitting to it a frame of a determined size filled up with wax-cloth; and it would not be impossible to ascertain by this machine the recoil of fire-arms, and consequently the strength of gun-powder.

This dynamometer, in its form and size, has a near resemblance to a common graphometer. It consists of a spring twelve inches in length, bent into the form of an ellipsis; from the middle of which arises a semicircular piece of brass, having engraved upon it the different degrees that express the force of the power acting on the spring. The whole of this machine, which weighs only two pounds and a half, opposes, however, more resistance than may be necessary to determine the action of the strongest and most robust horse. The simplicity of its mechanism will be better illustrated by the following description :

A, an elliptical spring, seen in perspective, covered with leather, that it may not hurt the fingers when strongly pressed on with the hands, (*see Plate XIII.*) This spring is composed of the best steel well welded and tempered, and afterwards subjected to a stronger proof than is indicated by its graduation, in order that it may not lose any of its elasticity by use.

B, a piece of steel strongly fastened to the spring by means of a claw and screws, in order to support a semicircular plate of brass **C**, mounted on the spring, seen geometrically. On this plate are engraved two arcs, one divided into myriagrammes, and the other into kylogrammes. Each of these arcs is still further divided by points, which express the weight in pounds *de marc*; and all these degrees having been exactly valued by accurate weights, it thence results that all dynamometers of this kind may be compared with each other.

Engraved by Lowry.

D, a small steel support, adjusted like the former to the other branch of the spring, and having a cleft towards its upper extremity to receive freely a small copper lever E, which is kept in its place by a small steel pin *a*. The whole of this mechanism is seen of its full size at H.

F, a steel index, very light and elastic, fixed upon its axis by a screw in the centre of the brass semicircle. This index has a small bit of leather or cloth glued upon the small circular part G, in order to render the friction on the plate easy, uniform, and almost insensible. It is to be observed, that this index is terminated by a double point, adapted to the divisions on both the semicircular arcs. The first, divided into myriagrammes and points, expressing ten pounds *de marc*, serves for all experiments which oblige the spring to be elongated in the direction of its greater axis, as is the case in trying the strength of the reins; in a word, for all trials where it is necessary to draw the spring by the two ends. The second, divided into kylogrammes and points, expressing pounds *de marc*, is destined for experiments which compress the two sides of the spring, as in trying the force of the hands.

J, a small plate of brass which covers the mechanism, to prevent it from being injured. This small plate has on it also a divided arc, the degrees of which correspond with those of the first arc of the machine; and by the play of a small index *b*, which is under the plate, the movements of the spring may be ascertained.

K, an aperture in the covering plate, through which may be introduced a small turn-screw, for the purpose of tightening or easing the index as may be necessary.

L, a pallet of brass, with a screw, having a cap like that on the needle of the mariner's compass, in which the lower pivot of the lever, that pushes round the index or handle, is made to play. This pallet, acting as a spring, yields to any sudden shock, and prevents the derangement of the mechanism.

M, a

M, a socket riveted on the plate **J**, in which the upper pivot of the lever turns.

N, N, N, small cylindric pillars that support the covering plate, which is fixed to them by three screws.

O, an iron rack, on the lower part of which the feet must be placed when it is intended to try the strength of a person's body.

P, a double handle of wood, with an iron hook, to be held at the same time in the two hands.

Q, a double hook made of iron, one end of which is to be hooked to the end of the spring, and the other to a rope fastened to a stake, as at *c*, when experiments are to be made on the strength of horses, or others, that require the dynamometer to be supported by hooks.

R, the manner of holding the dynamometer to ascertain the strength of the hands.

S, position of a man when trying the strength of his reins.

T, disposition of the dynamometer to try the strength of a horse or any other draught animal.

The effects of this machine may be thus explained : If a person presses on the spring with the hands, or draws it out lengthwise, by pulling the two extremities in a contrary direction, the two sides of the spring approach each other ; and in proportion as they are brought nearer, the small lever of the mechanism pushes before it the index, which, by the tightness with which it is screwed in its place, will remain at the point to which it has been brought by the pin *d*, in consequence of the force acting on the spring.

The muscular force of the arms, or rather the strength of the hands, may be tried by laying hold of the two sides of the spring nearest to the centre, as may be seen figure **R** ; so that the arms may be a little stretched, and inclined downwards, almost at an angle of 45 degrees. This position, which appears the most natural, is also the most convenient for a man to act with his full force. It is to be

recollected, that the lower arc of division, divided into kylogrammes, is that which serves to express the force of the hands, and of all the actions which press the two sides of the spring. The strength of the hands may also be tried one after the other; and if an account be kept of the degree of pressure of the right hand, and then of the left, and these two sums be added together, it will be found that the sum-total is, in general, equal to the strength of both the hands when acting together.

To try the strength of the body, or rather the reins, the person must place his feet on the bottom part of the rack O; one of the ends of the spring is then to be placed in one of the hooks of the rack; and the hook P is to be put into the other end. In this position the body is perpendicular; the shoulders only being inclined a little forwards, to be able, in throwing back the body, to pull the spring with all the force which a person is capable of exerting. In this situation, represented by S, a man may raise a great weight without being exposed to those accidents which might be occasioned by an effort made in a more constrained position.

Nothing can be more convenient than this dynamometer to ascertain and compare the strength of horses and that of all draught animals. Figure T shows, in a sufficient manner, the dispositions necessary for experiments of that kind. The trials I made on this subject are not extensive; but as they were conducted with care, they may serve to give a very just idea of the absolute force of horses of middling strength. For this purpose I employed four horses of middle size, in good health and well-conditioned, which were subjected separately and in succession to the same trial. The first drew equivalent to 36 myriagrammes; the second $38\frac{1}{2}$; the third $26\frac{1}{2}$; and the fourth 43. The sum of all these is 144 myriagrammes; and if we take the mean of this sum, we shall have, for the strength of ordinary horses, 36 myriagrammes, or 736 pounds *de marc*.