

THURSDAY, MAY 21, 1874

ON THE ACTION OF THE HORSE

NO dynamical problem, whether physical or biological, can be considered to be based on a substantial foundation until some method has been applied to it, by which an accurate statical record can be obtained of the exact relations of all the forces which, at any given moment, operate in its production. The great preparations which are just completed for the observation of the approaching transit of Venus show how difficult it sometimes is to obtain the desired results; and the value attached to the production of photographic records of the phenomenon proves the importance of permanent registration.

The movement of the legs of quadrupeds during progression is a difficult problem, as is shown by the fact that there are still many contradictory opinions maintained by high authorities on the subject. The difficulty in this case depends on there being the four different limbs to be considered at the same time, which it is impossible to do without a considerable amount of practice. Till lately, those who have studied the point, as far as the horse is concerned, have relied on their sight or hearing, and have checked their results by the impression left on the ground by the animal's hoofs. The observational power of each individual author has therefore always been an element in the problem, and it is very difficult to estimate the magnitude of that part of it, in any given case, correctly. Within the last few years, however, a much improved method has been introduced, which, judging from the discussion that has been carried on in the *Times* with reference to the attitude of the horse in Miss Thompson's picture of the "Roll Call," is but little known by some who have very decided opinions on the movement of the legs.

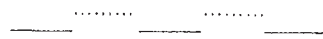
In a work, published last year, entitled "La machine Animale," by the eminent French physiologist, M. E. J. Marey, of Paris, a full account will be found of an apparatus constructed by the author, by means of which the movements of each of the legs of the horse during progression are synchronously registered on a uniformly moving strip of paper, in such a way that the tracings obtained from all the four can be superposed and compared at the leisure of the experimenter, and the simultaneous positions of each leg accurately estimated. What is more, M. Marey has also introduced a beautiful writing language, as it may be termed, by means of which it is as easy as in music to transcribe the results obtained with his instrument and read them off in their proper sequence. A knowledge of this language makes it possible to refer any given position, such as that of the horse in the "Roll Call," to it; from which it may be compared with the results obtained by direct experiment. Such being the case, it is not difficult to transfer the vagueness of "opinion" into the certainty of fact, and settle a question once for all.

M. Marey's method is the following:—The record of the movement of each limb is obtained by the employment of small caoutchouc bags filled with air, similar in most respects to those with which he has obtained such valuable information on the movements of the heart. Two of these bags are connected together by an india-rubber tube;

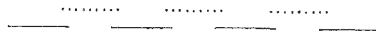
one is placed in contact with the foot, and the other with a small lever which writes on the recording paper. Each leg is provided with its pair of bags. Movements in either foot compress the bag connected with it, and this, by distending that at the other end of the tube, raises the lever. The levers write, one above the other, on a revolving drum held in the hand of the equestrian. We must refer our readers to the work itself if they desire to see the tracings obtained, mentioning that at the moment each foot touches the ground a sudden rise of the lever is the result, which is followed by an equally abrupt fall immediately it quits it.

Results even more satisfactory than those obtained by the use of the above-described air-bags might be obtained by adapting a simple electrical contact-maker and wirer to the shoes of the horses, which by acting on small electro-magnets would produce movements on levers which recorded similarly to those employed by M. Marey.

It will be necessary to give a short description of the mechanism of walking generally in order to explain that of the horse. Man in walking on level ground gives sufficient impulse to the body at each step to enable him to lift the one foot at the instant that the other touches the earth. Representing the time of contact of the right foot by a continuous line, that of the left foot by a superposed dotted line, and the exact period of the interval between the raising and lowering of either foot by the gap between the succeeding lines, the human walk on level ground would be drawn thus:—



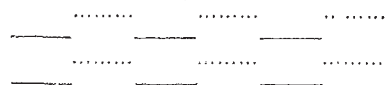
Whilst going uphill, however, there is a period during which both feet are on the ground together, which may be indicated thus:—



Whilst, again, in running, there are periods, as we all know, during which both feet are off the ground together thus:—



Turning to the case of the horse, and using the same method of illustration, we may employ the excellent comparison suggested by Dugès, in which he shows that any of its different steps may be imitated by two men, one behind the other. Now suppose these men, the hinder one with his hands on the shoulders of the one in front, to walk "in step," that is, with the right and left feet moving simultaneously; then, if their movements be recorded as above, with the steps of the hind man placed below those of him in front, the following would represent them:—



both would have their similar feet off and on the ground at the same time; and reverting to the horse, this formula, as it may be termed, which represents the legs of the same side off the ground together, is that of the "amble," a method of progression natural to the giraffe, but only acquired by special training in the horse.

Again, suppose that two men, instead of walking "in

step," do exactly the opposite, that is, place the *opposite* feet forward simultaneously ; we then have the following formula :—



All will recognise this as the "trot" in the horse ; although, as M. Marey has proved, there is always, in the true "trot," an interval between each of its two elements, during which all the feet are off the ground at once, thus :—



the upper of the last two formulæ, however, represents the walk of the elephant exactly.

In the amble and the trot, therefore, each complete series of steps is formed of two parts which never overlap ; it follows that the sounds produced by them are double also.

The walk of the horse is a phenomenon a little more difficult to realise at first sight. Again referring to the two men, suppose that they walk quite out of step, as it may be termed, in such a way that the front one *has raised* his right leg at the same moment that the hind one is *just raising* his, although they keep to the same number of steps. Such being the case the sequence of the steps would be *right front, left hind, left front, and right hind*, which is the order of succession in the horse, and may be represented thus :—



In this formula it is seen that at no time are there more than two feet on the ground at the same moment, and M. Marey states that in his numerous experiments such is always the case, except when a load is being taken down an incline in a wheeled vehicle, on which occasion three feet may be on the ground simultaneously. In the walk of the horse there are therefore four sounds produced in each complete series of steps, and these four are at equal or nearly equal intervals of time.

We are now in a position to judge of the accuracy of Miss Thompson's delineation of the "Roll Call horse," which is represented walking, with the left fore-foot fully raised from the ground, whilst the others are on it. The right fore-leg is nearly perpendicular and not bent ; that is, about half-way between the commencement and the end of its step. The left hind-foot is somewhat in front of the perpendicular axis of the leg ; that is, has just commenced its step ; and the right hind foot, though on the ground, is on the point of leaving it. As the animal is walking, the lengths of the steps and of the intervals must be represented, as shown above, as of equal duration, and the following is its expression, the thick vertical line representing the moment at which the painting figures it :—



By comparing this with the formula of the walking

horse, given above, it is evident that the representation is correct, except in a very slight point, which is that the right hind leg is on the ground, though just on the point of leaving it, whereas it ought to be just off it, because in walking there are never more than two legs on the ground at the same time. The general direction of the legs is quite correct. If the animal had been "ambling," the left hind-foot would have been off the ground, as well as the left fore. It is quite impossible to mistake the "walk" for the "trot," if their formulæ are compared and the positions at any given time worked out from them.

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CARPENTER'S "MENTAL PHYSIOLOGY"

*Principles of Mental Physiology.* By W. B. Carpenter, M.D., F.R.S. (Henry S. King & Co.)

THE title of the volume before us shows that its author is one of those philosophers—happily, an increasing number—who refuse to treat the phenomena of mind as though they were in no way connected with the body through which they find their expression. Mental Physiology is a comparatively new science, and does not date further backward than the days of Hartley. Before his time, and to some extent since, Physiology has been treated from what—to employ a word too often pressed into the service of a somewhat hazy idea—may be called the metaphysical point of view. The phenomena of mind have been abstracted from all their surroundings, and have been analysed by themselves, and the result has naturally been that we have been left but little wiser than before. Dr. Carpenter rejects this method, and bases his Psychology on the construction and working of the nervous system. But while shunning the metaphysical treatment of the subject, he does not adopt the other extreme, the doctrine, we mean, of the thorough materialist, who regards all mental phenomena without exception as the outcome of previous physical causes, which necessarily produce certain results. He steers a middle course, inasmuch as, while he advances the theory "of the dependence of the Automatic activity of the mind upon conditions which bring it within the nexus of Physical Causation," yet he believes in "an independent power, controlling and directing that activity, which we call Will."

This doctrine of the independence of the Will is the distinguishing characteristic of Dr. Carpenter's philosophy in the book before us ; it runs through the entire work as the one grand exception among a series of physical sequences, interdependent, and standing to each other in the relation of cause and effect, of antecedent and consequent. Yet, even to a mind which is not "trammelled by system," this splendid anomaly may seem strange and surprising, though the prevalence of the belief in a Free Will, even among scientific thinkers, need cause no wonder, so long as the ethical bias is not rigidly excluded from psychological speculation. It is the meritorious timidity of the moral side of human nature which says, "whatever else may be under laws of necessity, the Will at least is free and independent, for the alternative doctrine deprives all actions of their moral value, and reduces man to the level of a mere machine."

It is clear that Dr. Carpenter is not satisfied with the doctrine of the so-called necessarian school