experiment in 'frictional electricity'—so called. Given a house heated by a hot-air furnace or by steam, a floor covered with soft carpet which, in virtue of the furnace heat, is dry and warm, a man the soles of whose shoes are thoroughly dry, and electrification will probably result from every brisk movement of the man over the carpet. These conditions are most likely to be met with during cold winter weather, and it is then that the phenomena are generally noticed. It is not probable that Dr. Shufeldt's two friends can perform the feat of lighting gas in this way 'at all times and under all circumstances.' His statement that the "electrical discharge was considerably greater from the tip of the index finger than from any of the others of the hand, and gradually diminished in regular order as we proceeded to the little finger," is interesting, but needs confirmation. I am sceptical as to the charging of his entire system 'with this animal electricity,' and the results which followed such a condition, and particularly so as to the origin of the "sense of the most profound relief, as if it were that all the electricity of my system had been completely withdrawn by the act," which he experienced when his hand touched the back of the young mulatto girl. Is man one of the extremely small number of animals having specialized electrical organs? T. C. M.

Terre Haute, Ind., Feb. 22.

Inertia-force.

The importance of clear elementary ideas on the teaching of dynamics justifies me, I think, in asking space for a further discussion of Dr. E. H. Hall's 'inertia-force.'

In his letter published in *Science* of Feb. 18, Dr. Hall expresses the opinion that our difference with regard to 'inertia-force' is based upon a difference of interpretation of the term 'force.' That, I think, is not the case. With all his statements as to force in general I agree; and the passage which he quotes from Maxwell, as expressing his view of force with sufficient accuracy, expresses also my view with complete accuracy. Dr. Hall, indeed, says that this passage meets many of the points raised by me; and it would thus seem that it must be inconsistent with many of my positions. But I am unable to detect the inconsistency, and Dr. Hall merely asserts it without giving any proof.

I am in full agreement also with Dr. Hall, not in opposition to him as he supposes, when, passing from force in general to a particular case, he says that a ball swinging in a circle at the end of a string acts upon the string with a force directed from the centre. The ball certainly does exert such a force. I think it misleading to call that force centrifugal force, as he and many writers do; but that the force which he calls centrifugal force is an actual force is undoubted.

But when Dr. Hall proceeds to expound his 'inertia-force,' we seem to part company, perhaps because he has not given a complete specification of this force. He has told us its magnitude and its direction, but its place of application, the body on which it acts, he has left us to infer from the context, and my inference he calls in question. It would be useless for me to justify my inference, because in Dr. Hall's letter he modifies the statement of the pamphlet from which it was drawn, saying that what he meant was that "the inertia-force works [or acts] with the smaller applied force *against the agent which* exerts the greater force." From this modified statement I could not, of course, have made the inference referred to,—in fact, I could have made no inference at all; for it is couched in language which is not the current language of dynamics, which is not defined, and which I must confess I do not understand.

Let us, however, take Dr. Hall's new illustration, and see what light that throws on the place of application of inertia-force. "A train is being started by a locomotive. The forces *applied* to the train are the pull of the locomotive, and the smaller, opposing, force of friction. The pull of the locomotive prevails, but in prevailing it must deal not only with the resistance due to friction, but with the reaction (which also I call resistance) due to the inertia of the train," in other words, the inertia-force. Here, again, Dr. Hall uses terms not current in dynamics, and I do not understand what he means by the locomotive 'dealing with' both the frictional resistance and the inertia-force. Whatever may be the exact meaning of that phrase, however, it seems clear that if the inertia-force acts on the train, and if the pull of the locomotive has to deal with this force in moving the train, it must be expected to have some effect on the motion of the train. Yet if F is the pull of the locomotive, R the frictional resistance, M the mass of the train, and a its acceleration, we have undoubtedly, by Newton's second law of motion,

$$a = (F - R) \div M;$$

and hence the inertia-force is quite without effect on the motion of the train. It would seem, therefore, that the inertia-force cannot act on the train. Does it then act on the locomotive? If so, it can only be the force which the train exerts on the locomotive, which is of course equal and opposite to the above force F. But it cannot be this force; for if the brakes be put on the train, though the pull of the locomotive on the train—and therefore the force exerted by the train on the locomotive—may be kept constant, the acceleration of the train will change; and, according to Dr. Hall, the inertia-force must be proportional to this acceleration. Thus even this new illustration does not enable us to determine on what body the inertia-force acts.

This difficulty in determining the place of application of the inertia-force would be at once accounted for if it should be found to have no place of application at all, and I strongly suspect this to be the true conclusion. Dr. Hall seems to me, in fact, to have postulated a hypothetical force to account for the supposed resistance of a body to the action of an applied force, and to have thus fallen into the error referred to by Poisson in the following sentences:—

"Concevons qu'un corps soit posé sur un plan horizontal, et qu'il n'y soit retenu par aucun grottement. Si je veux le faire glisser sur ce plan, il faudra neanmoins, à cause de l'inertie de la matière, que j'exerce un effort quelconque. . . . J'aurai, dans chaque cas, le sentiment de l'effort que je serai obligé de faire; mais je ne devrai pas en conclure que la matière oppose aucune résistance à cet effort, et qu'il existe dans les corps ce qu'on appelle très improprement une *force d'inertie*. Quand on s'exprime ainsi, on confond la sensation que l'on a éprouvée, et qui resulte de l'effort qu'on a exercé, avec la sensation d'une resistance qui n'existe réellement pas" (*Traité de mécanique*, tome i. § 120). J. G. MACGREGOR.

Halifax, N.S., Feb. 22.